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THE MULTIPATHWAY HUMAN HEALTH RISK ASSESSMENT BASED ON THE SQI EMISSION RATES MEASURED DURING THE TRIAL BURN OF BASIN F LIQUID INDICATES THAT THE MAXIMUM LEVEL OF HUMAN HEALTH RISK ASSOCIATED WITH OPERATION OF THIS INCINERATOR WILL NOT EXCEED THE BENCHMARK RISK LEVELS DEFINED IN THE FINAL DECISION DOCUMENT (WOODWARD-CLYDE, 1990).

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BASIN F LIQUID INCINERATION PROJECT

DRAFT FINAL HUMAN HEALTH RISK ASSESSMENT

VOLUME II: APPENDICES

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INTERIM RESPONSE ACTION
BASIN F LIQUID INCINERATION PROJECT

DRAFT FINAL HUMAN HEALTH RISK ASSESSMENT

VOLUME II

APPENDICES

September 1993

Prepared by:

Roy F. Weston, Inc.
1 Weston Way
West Chester, Pennsylvania 19380

LIST OF APPENDICES

APPENDIX 1A

FINALIZATION OF BASIN F LIQUID INCINERATOR

HUMAN HEALTH MULTIPATHWAY RISK ASSESSMENT

SUBMERGED QUENCH INCINERATOR

PHASE I

7 SEPTEMBER 1993

SECTION 1
INTRODUCTION

Submerged Quench Incineration has been selected as the method to treat and dispose of 10.5 million gallons of Basin F liquid waste at the Rocky Mountain Arsenal (RMA), as described in the Interim Remedial Action for the RMA and the Final Decision Document (Woodward Clyde, 1990). In order to determine if the design specifications for the incinerator were acceptable from a human health perspective, a Final Draft Human Health Risk Assessment was submitted to the U.S. Army in July 1991 (WESTON, 1991). The goal of this risk assessment was to estimate the maximum potential risks which the SQI might pose to nearby residents, based on emission rates predicted from test burn data, waste stream analyses and hazardous waste emissions inventories. As stated in the Final Decision Document, the emissions from the SQI were considered protective of human health if the cancer risk did not exceed one-in-a-million (1E-06), and the non-cancer risk did not exceed a hazard index of one (1E+00) for the "reasonable maximum exposure". The emissions predicted from the SQI during its planned two year operation were associated with risks several orders of magnitude below these levels (WESTON, 1991).

Since the completion of the Final Draft Risk Assessment, several types of new information have become available that might impact the estimate of risk associated with operation of the incinerator. The potential impact of this new information is being analyzed in two phases, as follows:

Phase I

- Changes in Federal, State, or local regulations which apply to the operation of the SQI.
- Differences between the "as built" characteristics of the incinerator, compared to the "as designed" parameters used in the 1991 Risk Assessment.
- Changes in current exposure assumptions and toxicity values and methods compared to those employed in the 1991 Risk Assessment.

Phase II

- Changes in risk estimates based on measured emission rates during the Trial Burn of Basin F liquid, compared to the risk estimates based on predicted emission rates.

This report presents the results of the Phase I investigation. By agreement among the Army, the State, and the U.S. EPA, changes identified during Phase I will be incorporated into the revised risk assessment (Phase II) only if they cause a "significant" impact on the estimated risk. In this regard, a change is considered significant only if it causes the estimated total risk (cancer or noncancer) to approach the human health benchmarks established in the Final Decision Document (a total cancer risk level of 1E-06, and a Hazard Index of 1E+00). For example, a change that resulted in an increase in estimated cancer risk from 1E-14 to 1E-09 would not be considered significant (even though this is a 100,000-fold increase) because the change does not approach the benchmark of 1E-06. In contrast, a change from 1E-08 to 1E-07 would be considered significant because the increase could cause the total risk to approach the benchmark. Stated more formally, changes identified in Phase I are considered significant only if their implementation would result in an increase in total cancer risk of at least 1E-08 (1% of the cancer benchmark), or an increase in the Hazard Index of 1E-01 (10% of the noncancer benchmark).

SECTION 2

ANALYSIS OF NEW OR CHANGED REGULATIONS WHICH APPLY TO THE SQI

A discussion of regulations which were identified as being applicable or relevant and appropriate at the SQI, including a list of ARARs provided by the state, is provided in WESTON (1992a). This section of the Phase I Report summarizes and evaluates recent regulatory initiatives passed or proposed since 1991 (when the Final Draft Risk Assessment was completed) that are potentially applicable or relevant and appropriate to the operation of the SQI. Regulations which were reviewed but were found not to be applicable or relevant and appropriate are also briefly mentioned.

2.1 BOILER AND INDUSTRIAL FURNACE (BIF) REGULATIONS

The EPA promulgated final regulations on the burning of hazardous wastes in boilers and industrial furnaces (BIF) on 21 February 1991 (40 CFR 266.100). Because the SQI does not meet the definition provided in these regulation of either a boiler or a furnace, these regulations are not applicable. However, the State of Colorado does consider these regulations to be relevant and appropriate, so their potential impact was evaluated.

The BIF regulations set acceptable carcinogenic risk levels for four metals and acceptable off-site air concentrations for six noncarcinogenic metals. The allowable carcinogenic risk level is one chance in 100,000 (or 1E-05) for all four metals combined. The allowable off-site concentrations for the noncarcinogenic metals are established as reference air concentrations (RACs).

Table 2-1 presents the allowable off-site concentrations for these metals according to the BIF regulations. Also included in the table are the maximum annual off-site air concentrations for these metals that were predicted in the SQI risk assessment. As can be seen in the table, the predicted air concentrations of the applicable metals from the operation of the SQI are several orders of magnitude below the allowable levels. This strongly supports the conclusion that the risks from the operation of the SQI are below levels of concern.

Table 2-1

Allowable BIF Metal Concentrations Compared to SQI Levels

Carcinogenic Metals	BIF RSC[1] ($\mu g/m^3$)	SQI Maximum Annual Average ($\mu g/m^{3)}$
Arsenic	0.0023	0.000045
Beryllium	0.0041	0.00000046
Cadmium	0.0055	0.0000071
Chromium (VI)	0.00083	0.00000011
Non-carcinogenic Metals	BIF RAC[2] ($\mu g/m^3$)	
Antimony	0.3	0.0000080
Barium	50	0.000011
Lead	0.09	0.000014
Mercury	0.08	0.000013
Silver	3.0	0.0000012
Thallium	0.3	0.00012

[1]RSC - The Risk Specific Concentration is the ambient concentration which relates to a 1E-05 risk level based on a lifetime of exposure.

[2]RAC - Reference Air Concentration is the Reference Concentration (RfC) with an applied additional safety factor (typically 4).

The BIF regulations deal with organic pollutants by limiting emissions of carbon monoxide (CO) and hydrocarbons. Also, final permitting under these regulations requires a destruction and removal efficiency (DRE) of 99.99 percent. This is the same as the DRE already required for the SQI under the *Final Decision Document* (Woodward, Clyde, 1990) and current hazardous waste incinerator regulations (40 CFR 264.343).

2.2 RECENT AIR REGULATIONS PERTAINING TO ARARs

2.2.1 Introduction

Federal and State of Colorado air pollution control legislation and regulations were reviewed to determine if recently promulgated or proposed requirements could be deemed to be applicable or relevant and appropriate requirements (ARARs) for the SQI. The period of time considered was from January 1992 (the last time that ARARs had been reviewed) until May 1993.

2.2.2 Recent Federal Requirements

No recently promulgated federal requirements can be considered ARARs for the Basin F SQI. Although the Clean Air Act Amendments of 1990 (CAAA) established more stringent air pollution control standards than those currently in effect, the EPA has not yet implemented those standards with final rules which would apply to the Basin F SQI.

For purposes of completeness, EPA air regulations which could potentially constitute "to be considered" (TBC) materials [40 CFR 300.400(g)(3)] upon proposal and ARARs upon final promulgation are listed below with proposal dates:

- Hazardous Air Pollutants: Title III of the CAAA addresses source categories and subcategories of 189 listed hazardous air pollutants and requires EPA to establish maximum achievable control technology (MACT) standards. Potentially relevant source categories, along with scheduled dates for issuance of proposed standards, are listed below (57 FR 44147, 24 September 1992):

    - Hazardous waste incinerators - 15 November 2000.
    - Site remediation - 15 November 2000.

- Solid waste treatment, storage, and disposal facilities (TSDF) - 15 November 1994.

The SQI will not be impacted by the first two standards because operation of the facility will be completed well before the regulations are promulgated. Based on a recent court ruling, the SQI may be considered to be a TSDF, so regulations applicable to this source category might be applicable, if promulgated before the SQI ceases operation.

- Organic air emissions from tanks, surface impoundments, containers, and miscellaneous units at hazardous waste treatment, storage, and disposal facilities (TSDFs): EPA published a proposed regulation on 22 July 1991 (58 FR 33490) which will require that emission controls be installed and operated on tanks, surface impoundments, containers, and certain miscellaneous units at hazardous waste TSDFs if any hazardous waste having a volatile organic concentration equal to or greater than 500 ppm by weight is placed in the unit. The proposed regulation will be added as Subpart CC to 40 CFR Parts 264 and 265 when finally promulgated (scheduled for October 1993). However, available data on the composition of Basin F liquid (WESTON, 1992b) indicate that the total volatile organic content is well below 500 ppm, so it is very unlikely these regulations will be applicable. Even if Basin F liquid did have a volatile content above 500 ppm, the regulations would only impact the storage of Basin F liquids prior to incineration, and would not impact the operation of the SQI itself.

2.2.3 Recent State of Colorado Requirements

The BNA Environment Reporter was reviewed for changes to the State of Colorado's air pollution control requirements. In addition, the Colorado CDH Air Pollution Control Division was contacted regarding regulatory changes since late 1991. No new or revised regulations were discovered as of the date of this document.

The State of Colorado's statutory authority for air pollution control, the "Colorado Air Pollution Prevention and Control Act", was revised in 1992. Added to the Act was a provision for Colorado maximum achievable control technology (MACT) as provided in section 25-7-109.3. Colorado MACT is defined in the statute to be:

> "...standards imposed pursuant to section 25-7-109.3(3) utilizing principles of sound engineering judgment in applying the criteria set forth in section 112(d) of the federal act respecting the creation of standards or requirements which

provide for the maximum degree of emissions reduction that has been demonstrated to be achievable for the control of hazardous air pollutants, considering a cost-benefit analysis, economics, the cost and availability of control technology, the location, nature, and size of the source involved, and the actual or potential impacts on the public health, welfare, and the environment."

As part of the Colorado statute, Colorado MACT will not be more stringent than the MACT established by EPA for categories of sources unless EPA exempts sources from compliance with MACT because emissions from the sources are below threshold levels.

2.3 SUMMARY

No new federal or state regulations or ARARs were identified which will affect the operation of the SQI.

SECTION 3

DISPERSION AND DEPOSITION MODELING

3.1 OBJECTIVES

The exposure point concentrations employed in the 1991 Final Draft Risk Assessment were derived using an air dispersion and deposition model adapted from EPA's Industrial Source Complex Short Term (ISCST) model . This model requires as input several stack parameters (height, flow rate, exit temperature) as well as local meteorological data (wind speed, wind direction, precipitation). Since 1991, there have been several changes that might impact the calculation of dispersion and deposition rates. Specifically, 1) the EPA has identified changes in some parts of the basic model; 2) the stack has been built, and several test runs have been completed that provide information on the actual stack conditions; and 3) additional meteorological data have been collected. The potential impact of each of these changes is reviewed below.

3.2 BASIC MODEL

The air quality modeling analysis for the RMA SQI utilized the WESDEP model. This model is based on the ISCST (Version 86322) model and has been enhanced by WESTON to properly estimate the dry and wet deposition of pollutants emitted by sources similar to the SQI. Recently, the ISC model has been modified by the EPA to incorporate changes in the method used to calculate building/structural downwash effects on pollutant concentrations. The modified model is referred to the ISC2 model. The changes incorporated in the ISC2 model have not been incorporated to the WESDEP model because the changes only apply to stacks which are between 1.5 and 2.5 times the maximum projected width of the adjacent buildings. The SQI stack is less than 1.5 times the maximum projected width of the SQI building and therefore the changes to the ISCST model do not effect the air quality modeling analysis previously performed using the WESDEP model. Therefore, the WESDEP model and it's application to the SQI stack are not affected by the recent changes to the ISCST model.

EPA has also been working to develop another air dispersion and deposition model called COMPDEP. The COMPDEP model is based on the COMPLEX1 model and is capable of predicting dry and wet deposition totals at receptor locations both below and above the stack height. Both WESTDEP and COMPDEP use the California Air Resource Board (CARB) subroutine for calculating dry deposition velocities using Sehmels' curves, and include rainfall-dependent coefficients to calculate wet deposition totals. No direct comparison of the predictions of COMPDEP and WESTDEP have been performed at the SQI, so it is not possible to state whether one model yields higher predicted values than the other. However, the COMPDEP model is designed to address air dispersion and deposition in complex terrain, while the WESTDEP model is designed to be applicable to simple terrain. Because the terrain surrounding the SQI is basically flat, it is concluded that the WESTDEP model is most appropriate for use at this site.

3.3 STACK PARAMETERS

Table 3-1 compares the designed physical characteristics and operating conditions of the stack to the actual ("as-built") parameters and operating conditions measured during two test burns. The first test (Surrogate Run No. 4) employed 17% methanol in aqueous salt solution as the test material. The second test (100% Basin F miniburn) employed 100% Basin F liquid as the test material. As shown in Table 3-1, the exit temperature and exit velocity achieved during the test runs were quite close to the design specifications, ranging from just below (Surrogate Run No. 4) to just above (100% Basin F miniburn) the predicted values. The effects of these changes in the main stack physical and operating conditions on the ambient impact of the SQI were determined using the U. S. EPA SCREEN model to predict the maximum 1-hr concentration for the design and as built stack parameters. As shown in Table 3-2, the predicted maximum one-hour pollutant concentration ranged from 6% higher (based on the Surrogate No. 4 test) to 15% lower (based on the 100% Basin F miniburn) than the original value. There were also small differences in the distance to the location of the maximum predicted concentration (Table 3-2).

Table 3-1

"Design" *Vs.* "As Built" Stack Characteristics of the SQI

Parameters	Design[a]	As Built
Base Elevation (m)	1,578	1,578
Stack Height (m)	30.48	30.48
Inside Diameter (m)	1.02	1.07
Exit Velocity (mps)	14.8	13.2[b] 16.2[c]
Exit Temperature (°K)	354	349[b] 357[c]

[a]Final Draft Human Health Risk Assessment, July 1991, Table 6-1.
[b]Surrogate 4 Test Program Results, 9 April 1993.
[c]Shakedown No. 4, 100% Basin F Liquid Miniburn, 20-25 May 1993.

Table 3-2

Comparison of "Design" *Vs.* "As Built" Predicted Maximum One-Hour Concentrations and Distance From the SQI

SQI Condition	Maximum 1-hour Concentration ($\mu g/m^3$)	Distance 1-hour Maximum (m)
Design[a]	14.87	329
As Built	15.82[b] 12.63[c]	320[b] 352[c]

[a]As described in the Final Draft Human Health Risk Assessment, July 1993.
[b]Surrogate No. 4 Test Program results, 9 April 1993.
[c]Shakedown No. 4, 100% Basin F Liquid Miniburn, 20-25 May 1993.

3.4 METEOROLOGICAL DATA

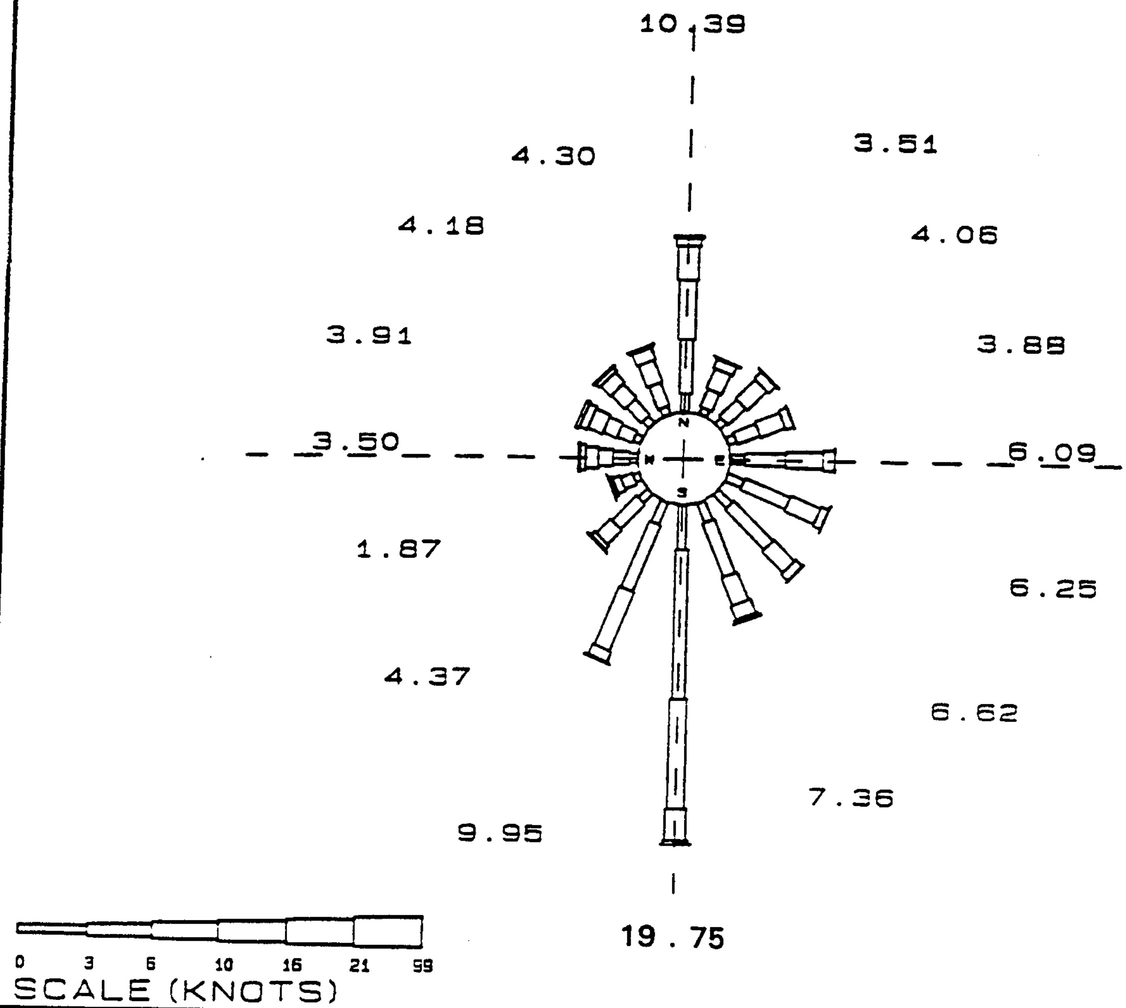
The effect of the change in meteorological data on the ambient impact of the SQI was determined qualitatively by comparing the most recent five years (1988-1992) of meteorological data to the five year database (1985-1989) utilized in the air quality modeling analysis of the Final Draft Human Health Risk Assessment. A five year composite windrose for each of five years of meteorological data from Denver Stapleton International Airport was developed and qualitatively compared to identify any significant changes in the wind direction patterns and/or distribution of wind speeds. The composite wind roses are presented in Figures 3-1 and 3-2. As seen from these figures, there are no significant changes in the wind patterns between the five years of meteorological data used in the air quality modeling analysis for the Final Draft Human Health Risk Assessment and the most recent five years of meteorological data.

3.5 DISCUSSION

Based on the screening air quality modeling analyses and an evaluation of the most recent meteorological data from Denver Stapleton International Airport, the air dispersion and deposition model predictions used in the 1991 Risk Assessment are very similar to those using the as-built characteristics of the SQI. Of the two test runs, the results from the 100% Basin F miniburn are considered to be most representative of conditions that will be achieved during SQI operation. As noted in Table 3-2, the data from this run indicate that the maximum 1-hour concentration is about 15% lower than predicted in the 1991 risk assessment. This correlates to a decrease in ambient air concentration of about 15%, and results in an equal reduction in the risk from the inhalation exposure pathway. These changes are shown in Table 3-3. The risks from the other exposure pathways would also tend to be lower, but the decrease would be less. The increase in distance to the location of maximum concentration is so small (only 23 meters) that changes in exposure point concentration at off-site receptor locations due to this change would be negligible.

FIGURE 3-1

DENVER, COLORADO
YEARS: 1985 THROUGH 1989
CALMS INCLUDED

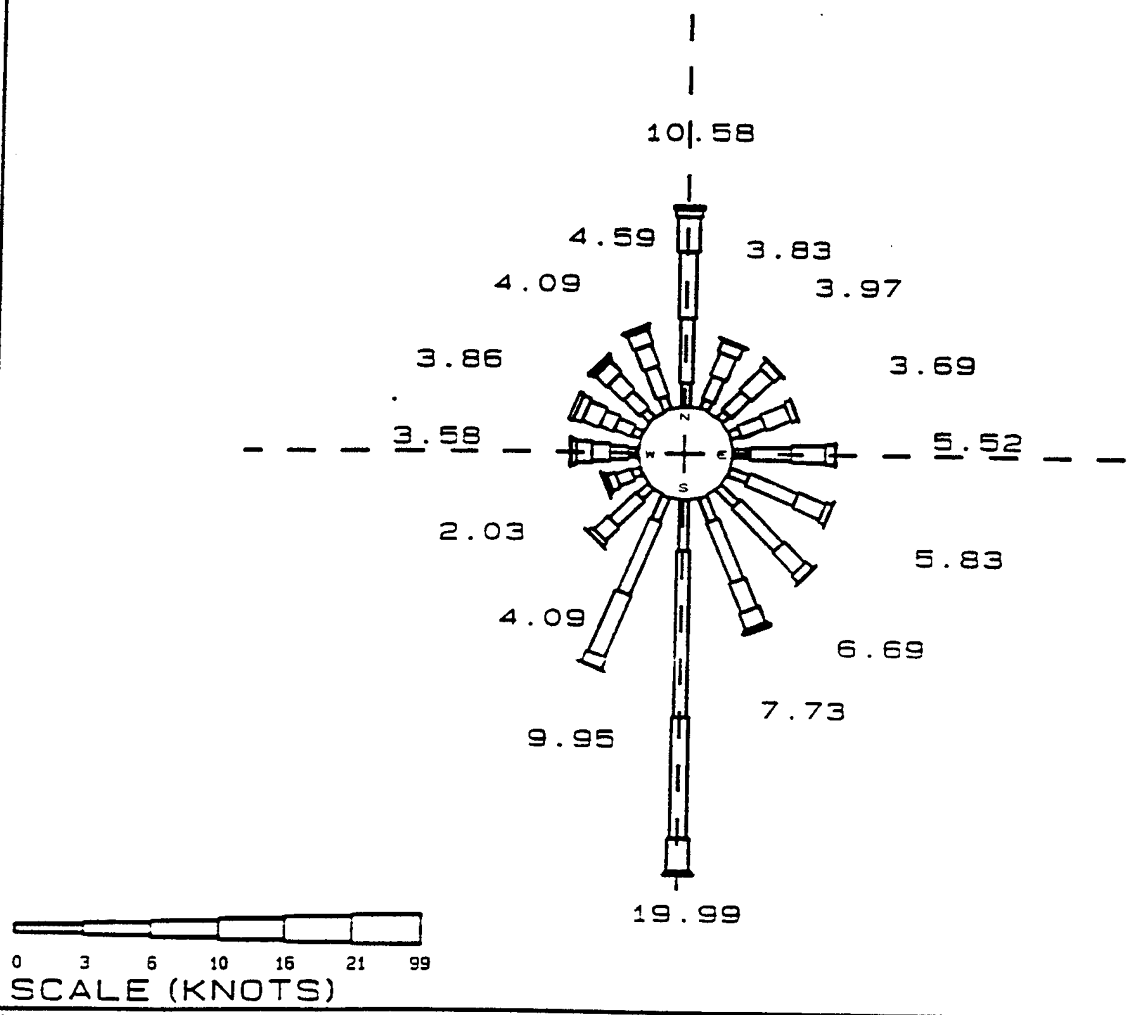


	WIND SPEED (KNOTS) 0-3	3-6	6-10	PERCENT OCCURRENCE 10-16	16-21	>21
N	1.08	3.25	3.48	1.98	0.42	0.18
NNE	0.43	1.13	1.28	0.54	0.10	0.02
NE	0.45	1.39	1.59	0.56	0.05	0.01
ENE	0.46	1.39	1.52	0.48	0.04	0.00
E	0.78	2.35	2.26	0.66	0.05	0.00
ESE	0.99	2.84	1.93	0.47	0.02	0.00
SE	1.08	3.23	1.73	0.53	0.04	0.00
SSE	1.22	3.33	1.74	0.84	0.18	0.05

	WIND SPEED (KNOTS) 0-3	3-6	6-10	PERCENT OCCURRENCE 10-16	16-21	>21
S	2.56	8.64	6.49	1.83	0.21	0.02
SSW	1.37	4.19	3.67	0.65	0.06	0.01
SW	0.73	2.06	1.18	0.29	0.09	0.03
WSW	0.38	0.74	0.47	0.20	0.06	0.03
W	0.47	1.00	0.87	0.74	0.29	0.13
WNW	0.42	0.97	0.88	0.94	0.46	0.23
NW	0.52	1.28	1.15	0.84	0.28	0.12
NNW	0.48	1.49	1.41	0.72	0.14	0.06

FIGURE 3-2

DENVER-STAPLETON INTERNATIONAL AIRPORT
1988 THROUGH 1992
CALMS INCLUDED



	WIND SPEED (KNOTS) 0-3	3-6	6-10	PERCENT OCCURRENCE 10-16	16-21	>21
N	1.21	3.42	3.51	1.87	0.39	0.18
NNE	0.49	1.31	1.31	0.60	0.09	0.03
NE	0.50	1.37	1.56	0.49	0.04	0.01
ENE	0.52	1.35	1.41	0.39	0.02	0.00
E	0.84	2.20	1.91	0.52	0.04	0.00
ESE	1.04	2.80	1.60	0.37	0.02	0.00
SE	1.30	3.23	1.60	0.50	0.04	0.01
SSE	1.37	3.49	1.69	0.93	0.16	0.08

	WIND SPEED (KNOTS) 0-3	3-6	6-10	PERCENT OCCURRENCE 10-16	16-21	>21
S	2.71	8.91	6.42	1.74	0.18	0.02
SSW	1.37	4.27	3.60	0.65	0.06	0.01
SW	0.78	1.97	1.01	0.28	0.04	0.01
WSW	0.46	0.87	0.45	0.18	0.06	0.02
W	0.51	0.96	0.92	0.81	0.26	0.11
WNW	0.46	0.95	0.81	0.94	0.46	0.23
NW	0.59	1.20	1.13	0.82	0.23	0.13
NNW	0.69	1.66	1.21	0.81	0.16	0.06

Table 3-3

Estimated Change in Risk Due to Change in Stack Conditions

Population	Estimated Change[a]	
	Cancer	Noncancer
Resident A	-1.7E-09	-2.5E-02[b]
Worker	-9.6E-11	-1.1E-03
Farmer	-6.1E-10	-8.6E-03[b]

[a]Based only on change in inhalation exposure.
[b]Based on child.

SECTION 4

NEW EXPOSURE AND TOXICITY ASSUMPTIONS

The Final Draft Human Health Risk Assessment prepared in 1991 employed exposure and toxicity values which were the best available at that time. Whenever existing guidance identified a range of possible values for a parameter, the most conservative value was employed. Since that time, the EPA has issued several new guidance documents relating to exposure assessment assumptions and has also revised a number of toxicity values. The potential impacts of these changes on risk estimates are discussed below.

4.1 NEW EXPOSURE ASSUMPTIONS

4.1.1 OSWER Directive 9385.6-03

In 1991, the EPA Office of Solid Waste and Emergency Response (OSWER) issued a directive which established a number of default exposure assumptions for residents, workers, and farm families. Table 4-1 compares the values used in the Risk Assessment with those recommended in the OSWER directive.

Changes which, if implemented, would result in an increase in estimated risk are as follows:

- The breathing rate for a worker was assumed to be 10 m^3 per day, while the OSWER directive suggests 20 m^3 per day. If 20 m^3/day were used, the estimated risk to the worker from the inhalation pathway would double. Because the inhalation pathway accounts for 94% of the total cancer risk to the worker, total cancer risk would also approximately double (from 6.8E-10 to 1.3E-09). However, this total cancer risk is still three orders of magnitude below the benchmark level of concern (1E-06). The inhalation pathway accounts for essentially 100% of the non-cancer risk to the worker, so the hazard index value would also double, from 7.5E-03 to 1.5E-02. This value is also well below the benchmark level of concern for non-cancer effects (HI > 1E+00).

- Ingestion of home-grown beef by the farmer was assumed to be 67 g/day in the risk assessment, compared to 75 g/day suggested by the OSWER directive. If implemented, this change would increase risk from this pathway by 12%. However, because the beef ingestion pathway contributes only a small fraction of the total risk (0.4% of the cancer risk and 0.03% of the non-

Table 4-1

Comparison of OSWER Default Values with Exposure Assumptions Used in the Risk Assessment

Population	Parameter	Used in Risk Assessment[a]	OSWER Directive
Resident[b]	Exposure Frequency (d/yr) Body Weight as infant (kg) Body Weight as child (kg) Body Weight as adult (kg)	365 9 15.5 70	350 -- 15 70
	Exposure duration as infant (yr) Exposure duration as child (yr) Exposure duration as adult (yr)	1 5 64	-- 6 24
	Breathing rate (m^3/day)	20	20
	Soil ingestion as child (mg/d) Soil ingestion as adult (mg/d)	200 100	200 100
	Fish ingestion (g/d)	4.8	54
Farmer	Vegetable ingestion (g/day)	127	80
	Beef ingestion (g/day)	67	75
	Milk ingestion (g/day)	305	300
Worker	Exposure frequency (days/year) Body Weight (kg)	250 70	250 70
	Soil ingestion (mg/day)	100	50
	Breathing rate (m^3/day)	10	20
	Exposure duration (year)	30	25

[a]WESTON 1991
[b]These values also apply to the farmer scenario.

cancer risk), implementation of this change would not result in a significant increase in total cancer or non-cancer risk.

- Ingestion of fish by area residents was estimated to be 4.8 g/day in the risk assessment, compared with 54 g/day identified as a default in the OSWER directive. The value of 4.8 g/day was based on a local creel survey, so this value is believed to be more applicable to the site conditions than the default value. If the default fish intake value were employed, total cancer risk estimates would increase as follows:

Population	Total Cancer Risk	
	4.8 g/day	54 g/day
Resident -A	1.4E-08	1.9E-08
Resident -B	3.6E-09	9.1E-09
Farmer	7.3E-09	1.3E-08

  Thus, even if fish intake were based on the default value, the total cancer risks would still remain well below the level of concern (1E-06). Use of the default fish intake rate would result in insignificant (less than 0.01%) increases in the noncancer hazard index for any of the populations considered.

- The risk assessment evaluated separately the exposure of infants (age 0 to 1, body weight = 9 kg) and children (age 1 to 6, body weight = 15.5 kg), while a value of 15 kg is recommended in the OSWER directive for children (age 0-6). This change, if implemented, would slightly increase both cancer and non-cancer risk estimates for residents, but the changes would be small (4% or less).

Changes which, if implemented, would result in a decrease in risk are as follows:

- The risk assessment assumed that a resident is exposed for 70 years, while the OSWER directive indicates that 30 years is a reasonable maximum value. If the exposure duration were assumed to be 30 years, an approximately twofold reduction would result in estimated cancer risk to residents. Non-cancer risk estimates would not be affected.

- The risk assessment assumed that a worker would be exposed for 30 years, while the OSWER directive indicates a reasonable maximum value is 25 years. If this change were implemented, a 17% decrease would result in estimated cancer risk to workers. Non-cancer risk estimates would not be affected.

- Soil intake by the worker was assumed to be 100 mg/day in the risk assessment, while the OSWER directive suggests a value of 50 mg/day. If implemented, the risk from the soil ingestion pathway would be reduced two-fold. However, the soil ingestion pathway contributes only 1.2% of the cancer

risk and only 0.003% of the non-cancer risk to workers, so this decrease would have very little effect on total risk to the worker.

- The risk assessment assumed that residents are exposed 365 days per year, while the OSWER directive indicates a value of 350 days per year is appropriate. If implemented, a small decrease (about 4%) would result in both the cancer and non-cancer risk estimates for residents.

- Intake of home-grown vegetables by an adult farmer was assumed to be a total of 127 g/day, while the OSWER directive indicates a value of 80 g/day is appropriate. If implemented, there would be a 37% decrease in the contribution from this pathway and this would result in a small decrease in estimated total cancer risk (from 7.3E-09 to about 6.8E-09). No significant change in the estimated total non-cancer risk to the adult farmer would occur.

Overall, if all of the values suggested by the OSWER directive were used, the changes that result in increased exposure and risk would tend to be balanced by those which decrease exposure and risk, and there would be no significant change in either cancer or noncancer risk (see Section 4.1.5). Even if only changes which increased risk were implemented, total cancer and non-cancer risk estimates would still be well below the benchmark levels of concern for all populations.

4.1.2 Dermal Exposure Assessment Guidance

In January 1992, the EPA issued a guidance document on dermal exposure assessment methods (EPA, 1992). Table 4-2 compares the recommendations provided in this document regarding estimation of absorbed doses from dermal contact with soil with values used in the risk assessment.

Changes which, if implemented, would tend to increase risk, include the following:

- A soil adherence factor of 0.51 mg/cm^2 was used in the risk assessment for children and adult residents. The EPA concluded a value of 0.2 was likely to be an average value and that 1.0 mg/cm^2 was a reasonable upper bound value. If a value of 1.0 mg/m^2 were employed instead of 0.51 mg/cm^2, the risk contributed by the dermal pathway would increase by a factor of approximately two. However, the risk contributed by dermal contact with soil for these populations is only a small fraction of the total ($\leq$1% for cancer, $\leq$0.01% for non-cancer). Therefore, this change, if implemented, would have little or no practical impact on total risk estimates.

Table 4-2

Comparison of 1992 EPA Recommendations on Dermal Exposure to Soil with Values Used in the Risk Assessment

Dermal Exposure Parameters	Used in Risk Assessment[a]	Recommendation by EPA (1992)
Soil adherence (mg/cm^2)	0.51 (resident adult, child) 1.5 (farmer, worker)	0.2 - 1.0
Exposure Frequency (d/yr)	117 (adult resident) 195 (children, workers)	40 - 350
Dermal Absorption Fraction TCDD Cadmium Other organics Other inorganics	 10% 1% 10% 1%	 0.1 - 0.3% 0.1 - 1.0% No value recommended No value recommended
Surface Area (cm^2) Child Adult	 2,500 4,500	 2,000[b] 5,000 - 5,800

[a]WESTON 1991
[b]Calculated as 25% of the average 95th percentile surface area for children ages 2 to 6.

- The risk assessment assumed that dermal exposure to soil occurred mainly during non-winter months, with estimated frequencies of 117 days/year for adult residents and 195 days/year for farmers, children and workers. The EPA guidance document supports the concept that exposure frequency is a very site-specific value, and encourages use of site-specific information in choosing the value. If the upper bound default value (350 days/year) were employed, risk from the dermal pathway would increase by a factor of about 1.8 (children, farmer) to 3.0 (adult resident). However, as noted above, the dermal pathway contributes only a small fraction to the total risk for residents and farmers, so this change, if implemented, would have little to no impact on total risk estimates. The dermal exposure pathway is somewhat more important for the worker, accounting for about 4.9% of total cancer risk. If it were assumed, by analogy to the resident, that the worker could be dermally exposed to soil up to 100% of the days on site (250 days/year), then total cancer risk to the worker would increase from 6.8E-10 to 6.9E-10.

- In the risk assessment, the surface area of an adult resident and an adult farmer exposed to soil was assumed to be 4,500 cm^2, compared to an upper bound default value of 5,000 to 5,800 cm^2 identified by EPA for residents. If a value of 5,800 cm^2 were assumed, risks to adult residents and farmers due to dermal exposure would increase about 1.3-fold. If this same value were applied to workers, dermal risks would increase about 1.8-fold. As noted above, because the dermal route contributes so little risk, none of these changes would result in a significant change in total cancer or non-cancer risk.

Some of the changes in guidance, if implemented, would tend to <u>decrease</u> risk estimates. These changes include the following:

- The risk assessment assumed that 10% of all semi-volatiles and 1% of all inorganics in soil on the skin would be absorbed. Based on a thorough review of available data, the EPA concluded that absorption of TCDD was about 0.1 to 3%, cadmium was about 0.1 to 1%, and that data were not sufficient to estimate reliable absorption fractions for other chemicals. If the upper bound range for TCDD (3%) were applied to all dioxins and furans, the estimated dermal contribution of this group of chemicals would decrease 3.3-fold. Because dioxins/furans were estimated to account for about 5 to 10% of the total dermal cancer risk, a 3 to 6% reduction in the estimated risk from this pathway would result. This would not result in a significant change in estimated total risk.

- In the risk assessment, the surface area of a child exposed to soil was assumed to be 2,500 cm^2, while the EPA suggests that 25% of the 95th percentile of body area is appropriate. Based on data provided by the EPA, this would be about 2,000 cm^2 for children (age 2 to 6). If this change were implemented, risk to children from dermal contact with soil would decrease by about 20%. This would not result in a significant decrease in total risk estimates.

4.1.3 Habicht Memo

In February 1992, the Deputy Director of the EPA (F. Henry Habicht) issued a memo which addressed the process of risk characterization. In brief, the memo stressed that exposure and risk estimates should not be thought of as discrete point values, but as a distribution or range of values that result from the inherent variability and uncertainty in exposure and toxicity terms. For this reason, the memo indicated that the risk assessment process should seek to describe variability and uncertainty in exposure and risk estimates, and present this information in the risk characterization section.

The most common means by which risk assessments have complied with this memo is by evaluating exposure and risk not only for the RME case, but also for people with average exposure. Differences between these two calculations are usually based on differences in assumed exposure duration, exposure frequency, and/or contact rates. Risks to individuals exposed under average conditions may be up to an order of magnitude lower than risks for individuals exposed under RME conditions, depending on which pathways are the main source of risk. In this risk assessment, the difference between average and RME would not be expected to be this large. This is because the main contribution to risk is the inhalation pathway, for which the main difference between average and RME is the assumed exposure duration. Since inhalation would be evaluated for an exposure duration of two years under both average and RME assumptions, the difference would therefore be quite small.

4.1.4 Guidance on Calculation of The Concentration Term

In May, 1992, the EPA issued an interim bulletin which reiterated earlier guidance that the concentration term used in exposure and risk calculations should be the upper 95th confidence limit of the arithmetic mean (UCL_{95}), and provided detailed instructions for how to calculate the value of UCL_{95} for both normal and lognormal data sets. This guidance will be followed in preparation of the revised risk assessment (Phase II). However, this guidance is not relevant to the risk calculations presented in the Final Draft Risk Assessment, because the release rates were predicted point estimates, not measured distributions.

4.1.5 Summary of Changes in Risk Estimates

Table 4-3 summarizes the magnitude of the changes in risk which would result if the new exposure parameters discussed above were used in the risk assessment. As shown, all of the changes (both singly and in combination) are below the criteria which would rank them as significant (see Section 1).

4.2 CHANGES IN TOXICITY ASSESSMENT

Evaluation of the risks from chemical exposures requires two quantitative toxicity values: 1) the slope factor, which describes the cancer risk per unit dose, and 2) the reference dose (RfD), which is believed to be the highest dose that does not pose a risk of any adverse non-cancer effects. The EPA and other groups concerned with the health effects of chemicals continuously review and update slope factors and RfDs as new toxicity data become available and as advances occur in the interpretation and extrapolation of toxicity data.

4.2.1 Changes in Slope Factors

Table 4-4 lists all of the carcinogenic chemicals evaluated in the risk assessment for which the slope factor has changed since the Final Draft was prepared. Table 4-5 summarizes the changes which these revised slope factor values would have on cancer risk estimates. The magnitude of these changes depends both on the change in the slope factor and also on the level of risk contributed by each chemical. The largest change would result from the 42-fold increase in the inhalation slope factor for nickel. The decrease for the other chemicals would have a smaller impact, because the amount of risk contributed by these chemicals is only a small percentage of the total risk. As Table 4-5 shows, changes in cancer risk estimates due to these changes in SF values are all less then 1E-08, and revised risk estimates using these new SF values are still well below the level of concern (1E-06).

The EPA is considering (but has not yet officially implemented) another method to evaluate the carcinogenic potency of PAHs. This is called the "toxicity equivalency factor" (TEF) method. In the risk assessment, it was conservatively assumed that all PAHs had the same

Table 4-3

Effect of New Exposure Parameters on Risk Estimates

Population	Parameter	Used in Risk Assessment	Current Default	Estimated Change in Risk	
				Cancer	Noncancer
Resident A	Fish Ingestion (g/day)	4.8	54	5.6E-09	0.0E+00
	Exp. Duration (yr)	70	30	-7.9E-09	0.0E+00
	BW as Child (kg)	15.5	15	2.4E-10	5.5E-03
	Exp. Frequency (d/yr)	365	350	-5.7E-10	-6.8E-03
	Soil Adher. Factor (mg/cm^2)	0.51	1.0	2.2E-11	1.4E-06
	Derm. Exp. Freq. (d/yr)	117	350	4.7E-11	1.2E-06
	Derm. Exp. Area (cm^2)	4500	5800	6.8E-12	-3.0E-07
	TCDD Abs. (%)	10	3	-1.1E-12	-4.0E-08
	Total			-2.6E-09	-1.3E-03
Worker	Breathing Rate (m^3/day)	10	20	6.4E-10	7.5E-03
	Exp. Duration (yr)	30	25	-1.1E-10	-1.3E-03
	Soil Ingest. (mg/day)	100	50	-4.0E-12	-1.1E-07
	Derm. Exp. Freq. (day/yr)	195	250	9.4E-12	2.5E-07
	Derm. Exp. Area (cm^2)	4500	5800	9.6E-12	2.6E-07
	TCDD Abs. (%)	10	3	-1.5E-12	-2.4E-08
	Total			5.4E-10	6.3E-03
Farmer	Beef Ingest. (g/day)	67	75	3.2E-12	1.5E-06
	Veg. Ingest. (g/day)	127	80	-4.8E-10	-7.4E-04
	Derm. Exp. Freq. (day/yr)	195	350	6.1E-11	1.1E-06
	Derm. Exp. Area (cm^2)	3200	5800	6.2E-11	1.2E-06
	TCDD Abs. (%)	10	3	-3.5E-12	-3.9E-08
	Total			-3.6E-10	-7.4E-04

Table 4-4

List of Chemicals for Which Slope Factor Values Have Changed

Direction of Change	Chemical Name	Exposure Route	SF (mg/kg-day)$^{-1}$ Original[a]	SF (mg/kg-day)$^{-1}$ New	Ratio
Increase	Nickel	Inhal.	2.0E-02	8.4E-01	42
Decrease	Carbon tetrachloride	Inhal.	1.3E-01	5.3E-02	0.41
	1,1-Dichloroethene	Inhal.	1.2E+00	1.8E-01	0.15
	Methylene chloride	Inhal.	1.4E-02	1.7E-03	0.12
	Benzo(a)pyrene	Oral	1.2E+01	7.3E+00	0.61
	Chrysene	Oral	1.2E+01	7.3E+00	0.61
	Dibenzo(a,h)anthracene	Oral	1.2E+01	7.3E+00	0.61
	Vinyl chloride	Oral	2.3E+00	1.9E+00	0.83

[a]WESTON 1991

Table 4-5

Summary of Total Cancer Risk Estimates Based on Original and Current Slope Factors

Population	Estimated Cancer Risk			
	Original Total[a]	Increase Due to Nickel	Decrease Due to Others	New Total
Resident A	1.4E-08	+4.6E-09	-3.9E-10	1.8E-08
Resident B	3.6E-09	+9.0E-10	-2.6E-10	4.2E-09
Farmer	7.3E-09	+1.6E-09	-4.1E-10	8.4E-09
Worker	6.8E-10	+2.5E-10	-6.0E-12	9.2E-10

[a]WESTON 1991

carcinogenic potency (slope factor) as benzo(a)pyrene. In the TEF approach, the estimated slope factor for each PAH is derived by multiplying the slope factor for benzo(a)pyrene by the TEF. Benzo(a)pyrene is believed to be the most potent PAH; therefore, all TEF values are equal to 1.0 or less. Thus, the risk contributed by PAHs will be the same or less when evaluated by the TEF method compared to the equal potency method. In the draft risk assessment, three carcinogenic PAHs were evaluated. For two of these (benzo(a)pyrene and dibenzo(a,h)anthracene), the TEF is 1.0. Thus, use of the TEF approach would not change the risk estimates for these chemicals. However, the third carcinogenic PAH (chrysene) has a TEF of 0.01. Thus, the cancer risk predicted from oral and dermal exposure to this chemical would decrease 100-fold. If implemented, this would result in a small decrease (0.5-3.5%) in the total cancer risk estimates for the populations evaluated.

4.2.2 Changes in Reference Doses

Table 4-6 lists all of the chemicals evaluated in the risk assessment for which RfD values have changed. Table 4-7 summarizes the effects these changes would have on estimated hazard indices for the populations assessed. As before, the magnitude of the change depends both on the change in the RfD and also on the amount of risk contributed by each chemical. (Even large changes in the RfD have little effect if the chemical contributes very little risk.) The largest change is an increase in the estimated inhalation hazard quotient for copper, with similar increases in estimated hazard quotients for nickel, hydrogen chloride and particulate matter. These increases in the estimated hazard indices are partially offset by a decrease in the inhalation hazard quotient for silicon. All other changes are sufficiently minor to be of negligible impact. If all of these changes were incorporated, the estimated total hazard index value would increase by a maximum of 2E-02, and all values would still be well below the level of concern (1E+00).

4.2.3 Changes in Methodology for Estimating Inhalation Risks

Since the time the risk assessment was prepared, the EPA has been moving toward a new method for estimating cancer and non-cancer risks following inhalation exposure. In this approach, cancer risk is described in terms of risk per unit concentration $(\mu g/m^3)^{-1}$, rather

Table 4-6

Summary of Chemicals for Which RfD Values Have Changed

Exposure Route	Chemical Name	RfD 1991[a]	RfD Current[b]	Direction and Magnitude of Change in HQ
Inhalation	Acetonitrile	1.00E-02	1.43E-02	1.4 times smaller
	Acrylonitrile	4.39E-03	5.71E-04	7.7 times larger
	Benzene	3.26E-02	3.06E-04	106.5 times larger
	Bromomethane	1.71E-02	1.43E-03	12.0 times larger
	4-Chlorobiphenyl	2.45E-02	5.10E-04	48 times larger
	1,2-Dichloropropane	3.54E-01	1.14E-03	310.5 times larger
	1,3-Dimethylbenzene	2.00E-01	1.02E-04	1960.8 times larger
	Ethylbenzene	4.43E-01	2.86E-01	1.5 times larger
	Hexachlorobenzene	8.00E-04	2.55E-05	31.4 times larger
	Parathion	5.10E-05	1.02E-04	2.0 times larger
	Styrene	2.17E-01	2.86E-01	1.3 times smaller
	Tetrachlorethene	3.46E-01	1.73E-01	2.0 times larger
	Toluene	5.71E-01	1.14E-01	5.0 times larger
	Vapona	8.00E-04	9.18E-04	1.15 times smaller
	Xylenes	8.57E-02	4.43E-01	5.2 times smaller
	Ammonia	1.73E-02	2.86E-02	1.7 times smaller
	Arsenic	2.04E-04	1.02E-04	2.0 times larger
	Boron	4.11E-03	5.71E-03	1.4 times smaller
	Cadmium	5.10E-05	2.04E-06	25.0 times larger
	Calcium	1.46E-03	2.04E-03	1.4 times smaller
	Cobalt	5.10E-05	2.04E-05	2.5 times larger
	Copper	1.00E-02	1.02E-03	9.8 times larger
	Hydrogen cyanide	5.10E-03	1.12E-02	2.2 times smaller

Table 4-6 (continued)

Summary of Chemicals for Which RfD Values Have Changed

Exposure Route	Chemical Name	RfD 1991[a]	RfD Current[b]	Direction and Magnitude of Change in HQ
	Lithium	1.00E-04	2.55E-05	3.9 times larger
	Magnesium	6.15E-03	1.02E-02	1.7 times smaller
	Manganese	3.00E-04	1.14E-04	2.6 times larger
	Nickel	1.02E-04	5.10E-05	2.0 times larger
	Silicon	5.10E-05	1.02E-02	200.0 times smaller
	Titanium	6.11E-03	1.02E-02	1.7 times smaller
	Zinc	8.19E-03	1.02E-02	1.2 times smaller
	Carbon monoxide	4.08E-02	2.96E-02	1.4 times larger
	Hydrogen chloride	7.65E-03	2.00E-03	3.8 times larger
	Particulate matter	4.29E-02	1.43E-02	3.0 times larger
Oral	Acetonitrile	6.00E-02	6.00E-03	10.0 times larger
	1,2-Dichloroethene	2.00E-02	1.00E-02	2.0 times larger
	Arsenic	1.00E-03	3.00E-04	3.3 times larger
	Selenium	3.00E-03	5.00E-03	1.7 times smaller
	Silver	3.00E-03	5.00E-03	1.7 times smaller
	Zinc	2.00E-01	3.00E-01	1.5 times smaller

[a]Value used in the 1991 Draft Final Risk Assessment
[b]Value currently listed by EPA in IRIS or HEAST.

Table 4-7

Summary of Total HI Estimates Based on Original and Current RfD Values

Population	Original Total HI[a]	Estimated Change[b]	Revised Total HI
Adult Resident A	7.4E-02	+1.0E-2	8.4E-02
Adult Resident B	1.5E-2	+2.0E-3	1.7E-2
Farmer	2.6E-2	+4.0E-3	3.0E-2
Worker	7.5E-3	+1.1E-3	8.6E-3
Child Resident A	1.7E-1	+2.0E-2	1.9E-1
Child Resident B	3.4E-2	+5.0E-3	3.9E-2
Child Farmer	6.0E-2	+8.0E-3	6.8E-2
Infant Resident A	1.1E-1	+2.0E-2	1.3E-1
Infant Resident B	2.4E-2	+3.0E-3	2.7E-2
Infant Farmer	4.1E-2	+6.0E-3	4.7E-2

[a]As presented in the 1991 Draft Final Risk Assessment (WESTON 1991).
[b]Based on changes in RfD values shown in Table 4-6.

than risk per unit dose (mg/kg-day)$^{-1}$. Similarly, safe exposure limits for non-cancer effects are expressed in terms of a reference concentration (RfC) (μg/m^3), rather than a reference dose (mg/kg-day). The concept behind this change is that the effects of some inhaled chemicals are more related to their concentrations in air than to the amounts absorbed (dose). For example, this concept applies to irritants such as acid vapors.

Typically, the RfC and the RfD approach give equal risk results for adult residents. However, differences could result when other populations (children, workers, etc.) are evaluated. For example, the RfC approach would usually be expected to yield a lower estimate of non-cancer risk for children because an adjustment for the higher breathing rate per unit body weight of children would no longer be applied. Conversely, the RfC approach would be expected to yield a slightly higher estimate of non-cancer risk for workers because the adjustment for an exposure frequency of 250 days/yr would no longer be applied.

Because the EPA has not yet issued guidance on which chemicals are better evaluated using the RfC than the RfD approach, this method is not yet generally employed, and will not be used in the revised risk assessment.

SECTION 5
CONCLUSIONS

This Phase I report investigated the potential impacts of regulations, data, and EPA exposure and toxicity values that are different than those used in 1991 when the Final Draft Human Health Risk Assessment (WESTON 1991) was prepared.

As discussed in Section 2, no new regulations or ARARs were identified which impact the operation of the SQI. As discussed in Sections 3 and 4, some of the changes in operating conditions and in exposure and toxicity values would have small impacts on the estimated risk levels to humans. These changes are summarized in Table 5-1. As shown in this table, all of the changes in estimated cancer risk are less than 1E-08, and all of the changes in estimated noncancer risk (expressed as the Hazard Index) are less than 1E-01. Therefore, in accord with the discussion and definition presented in Section 1, it is concluded that none of these changes would result in a significant impact on the risk estimates originally presented in the Final Draft Risk Assessment, and none will be incorporated into the revised risk assessment.

Table 5-1

Summary of Changes in Risk Estimates

Population	Basis of Change in Estimated Risk	Magnitude of Estimated Change	
		Cancer Risk	Noncancer Risk
Resident A	Stack Conditions	-1.7E-09	-2.5E-02
	Exposure Parameters	-2.6E-09	-1.3E-03
	Toxicity Values	4.2E-09	2.0E-02
	Total	-9.0E-11	-6.3E-03
Worker	Stack Conditions	-9.6E-11	-1.1E-03
	Exposure Parameters	5.4E-10	6.3E-03
	Toxicity Values	2.4E-10	1.1E-03
	Total	6.9E-10	6.3E-03
Farmer	Stack Conditions	-6.1E-10	-8.6E-03
	Exposure Parameters	-3.6E-10	-7.4E-04
	Toxicity Values	1.2E-09	8.0E-03
	Total	2.2E-10	-1.3E-03

REFERENCES

EPA (U.S. Environmental Protection Agency), 1989. *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A*. Interim Final. Office of Emergency and Remedial Response (OERR), Washington, D.C. EPA/540/1-89/002.

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APPENDIX 1B

RESPONSE TO AGENCY COMMENTS ON DRAFT PHASE I REPORT

7 SEPTEMBER 1993

SECTION 1
INTRODUCTION

The State of Colorado and the U.S. EPA (Region VIII) were provided draft copies of the Phase I report. Provided below is a summary of the comments received from these agencies, along with a description of the revisions which were made in response to the comments.

SECTION 2

COMMENTS FROM THE STATE OF COLORADO

Comment: The Colorado Department of Health considers the BIF regulations to be relevant and appropriate.

Response: The text has been revised to reflect this, and a discussion has been added to show that the emissions from the SQI comply with the BIF regulations.

Comment: Clarify why the SQI does not meet the definition of a TSDF.

Response: Based on a recent ruling by the 10th Circuit Court of Appeals, the SQI may be considered a TSDF. The text has been modified to reflect this.

Comment; The State has provided a list of ARARs in a letter dated December 18, 1991.

Response: The risk assessment does not specifically focus on the issue of ARARs, but the text of Section 2 of the Phase I report (Appendix 1 to the risk assessment) has been modified to cross-reference to the 1992 Implementation Document which does discuss ARARs, including those provided by the State.

Comment: It would be helpful in Sections 4.1 and 4.2 to identify which changes are significant and which are insignificant.

Response: Section 4.1.5 provides a summary showing that none of the changes identified in Section 4.1 are significant. The text in Section 4.2 has been modified to indicate that the same is true for changes discussed in this section. Section 5 also provides a summary showing that none of the changes are significant.

Comment: The January 1992 EPA guidance document on dermal exposure should be cited.

Response: A citation was added as suggested.

SECTION 3
COMMENTS FROM EPA REGION VIII

Comment: In Section 4.2, it should be stated whether or not Tables 4-6 and 4-7 include the effect of changes in exposure parameters discussed in earlier sections.

Response: The tables summarize only the effects of changes in toxicity values, and do not include the effects of changes in exposure parameters. The titles of the tables have been revised to make this apparent. A summary of the combined effects of all changes is presented in Section 5.

Comment: The column labeled "Direction and Magnitude of Change in RfD" in Table 4-6 gives values that are opposite of the correct values.

Response: The table has been corrected by changing the column heading to indicate that the changes shown are for the HQ values (which are inversely related to the changes in the RfD values).

APPENDIX 3A

DATA ON DESIGNATED FISHING AREAS

STATE OF COLORADO
Roy Romer, Governor
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WILDLIFE

AN EQUAL OPPORTUNITY EMPLOYER

Perry D. Olson, Director
6060 Broadway
Denver, Colorado 80216
Telephone: (303) 297-1192

REFER TO:

October 3, 1990

Nathan Mottl
Roy F. Weston Inc.
1 Weston Way   Bldg. 51
West Chester, PA   19380

Dear Mr. Mottl:

In response to your telephone request, I am providing the following information:

Within a 5 km radius of the center of the Rocky Mountain Arsenal we are only aware of the ponds on the Arsenal as being open to public (although limited) fishing.

Within a 5-10 km radius, we have identified 7 ponds which are open to public fishing, four of which are at the same site. Here are the names and locations of the ponds:

Clear Creek Pond	Adams County	T3S, R68W, S2
Engineer's Lake	Adams County	T2S, R68W, S36
Rotella Park Pond	Adams County	T2S, R68W, S35
Grandview Ponds 1-4	Adams County	T2S, R67W, S18

Here is a summary of recent fish stocking information:

Clear Creek Pond - not stocked, but fish are present and fishing takes place

Engineer's Lake

1985: Stocked with 1100 4" Channel Catfish
1987: Stocked with 800 4" Largemouth Bass and 1500 6" Channel Catfish

Rotella Park Pond

1985: Stocked with 100 7" Bluegills

Grandview Pond #1

1988: Stocked with 20 15" Hybrid Grass Carp and 100 7" Largemouth Bass

Grandview Pond #2

1988: Stocked with 40 12" Hybrid Grass Carp and 200 7" Largemouth Bass

(continued)

Grandview Pond #3

1988: Stocked with 10 12" Hybrid Grass Garp and 100 7" Largemouth Bass

Grandview Pond #4

1988: Stocked with 20 12" Hybrid Grass Carp and 100 7" Largemouth Bass

The attached map shows the location of all 4 areas and provides some additional data - I have drawn in Grandview Ponds on it.

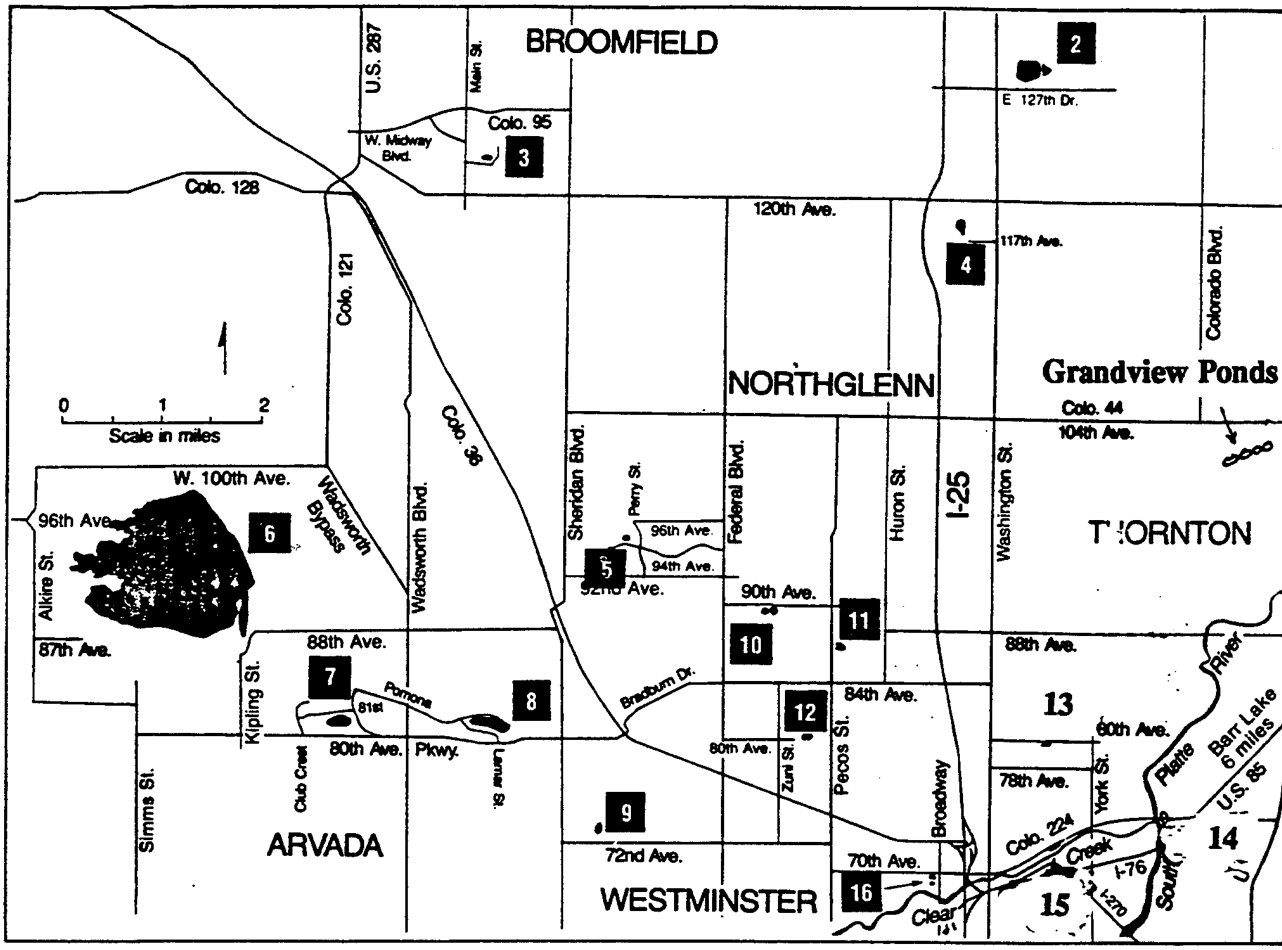
Let me know if you have any questions.

Sincerely,

Dave Weber

Dave Weber
Habitat Biologist

cc: Jim Satterfield, Pat Tucker



bass, yellow perch, and rainbow trout (catchable size stocked).

Agency: Adams County Parks & Recreation.

Comments: Open 5 a.m. to 11 p.m. No boats. Fishing pier on the south shore. Playground and restrooms. Extreme water level fluctuation. Hard surface foot trail.

5 Butts Park Pond

Location: Northwest of the intersection of W. 94th Ave. and Perry Street. Parking area is off of Perry Street just south of 96th Ave. or off of 94th Ave. next to the ice rink.

Size: 3 acres; 5 feet maximum depth.

Fish: Bluegill, bullhead, channel catfish, crappie, green sunfish, sucker, and yellow perch.

Agency: Hyland Hills Recreation & Park District.

Comments: Open daylight hours. No boats. Recreation Center and playground.

6 Standley Lake

Location: W. 88th Ave. and Kipling Street. Parking area is off of Kipling. Access also on the west side of the lake via Alkire Street at 87th Ave.

Size: 1,210 acres; 80 feet maximum depth.

Fish: Bluegill, carp, channel catfish, green sunfish, largemouth bass, smallmouth bass, sucker, walleye, yellow perch, and rainbow trout (catchable size stocked).

Agency: South and southwest shore, Jefferson County Open Space. Remaining shore and lake itself, City of Westminster Parks & Recreation.

Comments: Open 5 a.m. to 11 p.m. for walk-in visitors. Open 8 a.m. to 7 p.m. for vehicles and boats. All boats need Westminster boat permit. Fee area for vehicles at Kipling & W. 88th Ave. Walk-in fishing is free. Extreme water level fluctuation. Two boat ramps on east shore. No fishing from dam.

MAY BE CLOSED DUE TO INSURANCE PROBLEMS: CONTACT MANAGING AGENCY.

7 Pomona Lake,

Location: In Meadow Glen Park. North of W. 80th Ave. and one-quarter mile west of Wadsworth Blvd. Main parking area can be reached via 80th Ave. by going north on Club Crest Drive, and then east on W. 81st Place.

Size: 31 acres; 8 feet maximum depth.

Fish: Largemouth bass, yellow perch, bullhead, channel catfish, crappie, and green sunfish.

Agency: North Jeffco Parks & Recreation.

Comments: Open dawn to 11 p.m. No boats. Hard surface foot trail.

8 Lake Arbor

Location: North of W. 80th Ave. between Wadsworth Blvd. and Sheridan Blvd. Both the north and south shores of the lake can be reached via 80th Ave. To reach the south shore, take 80th Ave. to Lamar Street. Go north on Lamar to 80th Place. Take 80th Place east to the cul-de-sac. To reach the north shore take Lamar Street north past 80th Place on to Pomona Drive. Go east on Pomona around the north end of the lake to the parking area.

Size: 37 acres, 19 feet maximum depth.

Fish: Bluegill, bullhead, carp, channel catfish, crappie, green sunfish, largemouth bass, pumpkinseed sunfish, and sucker. Grass carp stocked to control aquatic plants.

Agency: North Jeffco Recreation & Park District and City of Arvada.

Comments: Open dawn to 11 p.m. Non-motorized boats only. Fishing piers located on the north shore. Artificial fish habitat structures in lake. Playground. Hard surface foot trail.

9 Faversham Park Pond

Location: Sheridan and 72nd Ave.

Size: 6 acres; 11 feet maximum depth.

Fish: Bluegill.

Agency: City of Westminster Parks & Recreation.

Comments: Open sunrise to 11 p.m. No boats. No wading or swimming. Kids 15 years old and under.

10 Camenisch Park Pond

Location: West of Pecos Street, south of W. 90th Ave. at Fontaine Street. Parking area south of 90th Ave.

Size: 3 acres; 10 feet maximum depth.

Fish: Largemouth bass, pumpkinseed sunfish, sucker, bluegill, bullhead, channel catfish, crappie, and green sunfish.

Agency: Hyland Hills Recreation & Park District.

Comments: Open dawn to 10 p.m. No boats. Playground and restrooms. Hard surface foot trail.

11 Bell Roth Park Pond

Location: On the east side of Pecos Street, 2 blocks north of W. 84th Ave.

Size: 3 acres; 8 feet maximum depth.

Fish: Channel catfish, crappie, green sunfish, sucker, yellow perch, bluegill, bullhead, and carp.

Agency: Hyland Hills Recreation & Park District.

Comments: Open dawn to 10 p.m. No boats. Playground.

12 Kiwanis Park Pond

Location: W. 80th Ave. east of Zuni Street. Parking area south of 80th Ave.

Size: 3 acres; 2 feet maximum depth.

Fish: Bullhead and green sunfish.

Agency: Hyland Hills Recreation & Park District.

Comments: Open dawn to half hour after sunset. No boats.

13 Rotella Park Pond

Location: North of E. 78th Ave. between N. Washington Street and N. York Street. Parking north of 78th Ave. or south of Coronado Drive So.

Size: 3 acres; 10 feet maximum depth.

Fish: Bluegill, bullhead, channel catfish, largemouth bass, and pumpkinseed sunfish.

Agency: Adams County Parks.

Comments: Open 7 a.m. to 11 p.m. No boats. Extreme water level fluctuation. Playground and restrooms. Hard surface foot trail.

14 Engineers Lake

Location: From I-76 go to Hwy 224. Travel west on 224. Parking area is south of 224, just west of the South Platte River. The lake is at the confluence of Clear Creek and the South Platte River. Hard surface foot trail across the river.

Size: 11 acres; 25 feet maximum depth.

Fish: Bullhead

Agency: Adams County Parks & Recreation.

Comments: Open 7 a.m. to 11 p.m. No boats. Walk-in trail and ~~steep shoreline.~~ Picnic shelter.

15 Clear Creek Pond

Location: South of Hwy 224 between Washington Street and York Street. Parking area is south of Hwy 224, and east of Washington Street.

Size: 3 acres; 9 feet maximum depth.

Fish: Bluegill, bullhead, carp, channel catfish, crappie, green sunfish, largemouth bass, pumpkinseed sunfish, and yellow perch.

Agency: Adams County Parks & Recreation.

Comments: Open 7 a.m. to 11 p.m. No boats. Hard surface trail along south side of pond.

16 Twin Lakes Park Ponds

Location: Just west of Broadway on 70th Ave. Parking area south from 70th Ave.

Size: 2 ponds; 7 acres total; 16 feet maximum depth.

Fish: Bullhead, carp, channel catfish, crappie, green sunfish, largemouth bass, sucker, and yellow perch.

Agency: Adams County Parks.

Comments: Open 7 a.m. to 11 p.m. No boats. Hard surface foot trail, which connects with Clear Creek Trail.

17 Arvada Reservoir (not shown on map)

Location: Between Highway 93 and Indiana on W. 66th Ave.

Size: 180 acres; 77 feet maximum depth.

Fish: Rainbow trout, walleye, largemouth bass, smallmouth bass, yellow perch.

Agency: City of Arvada

Comments: City of Arvada permit required; available only at Arvada City Hall. No ice fishing. Non-motorized boats only. Open dawn to dusk. Special regulations apply.

18 Carl Park Pond

Location: West of Federal Blvd., on W. 54th Ave. at Meade Street. Parking area north of 54th Ave.

Size: 4 acres; 8 feet maximum depth.

Fish: Largemouth bass, bluegill, and bullhead.

Agency: Hyland Hills Recreation & Park District.

Comments: Open dawn to 10 p.m. No boats.

19 Birdland Lake

Location: W. 51st Ave. and Garrison Street. Parking area west of Garrison at south end of the lake.

Size: 3 acres; 10 feet maximum depth.

Fish: Bluegill, channel catfish, green sunfish, largemouth bass, pumpkinseed sunfish, and yellow perch.

Agency: North Jeffco Recreation & Park District.

Comments: Open dawn to 11 p.m. Non-motorized boats only. No ice fishing. Playground and hard surface foot trail.

20 Ward Road Pond

Location: Northeast of the intersection of I-70 and Ward Road. Parking area east of Ward Road and south of W. 48th Ave.

Size: 7 acres; 30 feet maximum depth.

Fish: Largemouth bass, pumpkinseed, bluegill, bullhead, crappie, and green sunfish.

Agency: City of Arvada and Division of Wildlife.

Comments: Non-motorized boats only. Belly-boats allowed. Pond open for fishing only. Good bass fishing. Restrooms.

Special Regulations: 1. Fishing by artificial flies or artificial lures only; 2. All fish caught must be returned to the water immediately.

New Ponds Not Yet In Guide

Lowell Ponds - Adams County- At Lowell Street and 56th Way
Size: 3 ponds - 11 acres, 2 acres, 2 acres + Sheets Lake, 5 acres leased from City of Westminster. Maximum Depth - 10 feet.
Fish: Largemouth and smallmouth bass, channel catfish, bluegill, crappie and bullhead.
Agency: Colorado Division of Wildlife
Comments: Belly boats allowed for fishing, except on Sheets Lake.
Special Regulation: All largemouth and smallmouth bass possessed must be 15 inches or longer.

Ketner Lake - Jefferson County - Off of 100th Ave. and County Side Drive
Size: 25 acres
Agency: City of Westminster
Fish: Largemouth bass, crappie, bluegill, green sunfish, yellow perch and bullhead
Comments: Belly boats allowed for fishing but no other types of boats. Ice fishing is prohibited. Special Regulation: All largemouth & smallmou bass possessed must be 15 inches or longer.

Grandview Ponds Adams County - Off of 104th and Riverdale Road
Size: 4 ponds - 10 acres total
Agency: Colorado Division of Wildlife
Fish: Largemouth bass, bluegill, channel catfish, crapppie, bullhead, green sunfish and yellow perch.
Special Regulation: All largemouth and smallmouth bass possessed must be 15 inches or longer.

Adams County Fairgrounds Lake (Public Works Lake) - Adams County - Off of 124th at Adams County Fairgrounds.
Size: 20 acres
Agency: Adams County Parks and Recreation
Fish: Largemouth bass, blurgill, channel catfish, crappie and yellow perch.
Special Regulation: All largemouth and smallmouth bass possessed must be 15 inches or longer.

Boating Changes

Cottonwood Park Lake - Page 9 - No boating is allowed.
Kendrick Reservoir - Page 9 - No boating is allowed
Quincy Reservoir - Page 12 - Boat rental available
Own boat allowed with Aurora permit - Non-motorized boats only
Waneka Lake - Page 14 - Boat rental now available

Phone Number Changes

Bear Creek Reservoir - 987-7880
Chatfield Reservoir - 791-7275
Foothills Parks & Recreation - 987-3602

AGENCY CHANGES

Webster Lake - Page 4 - Agency: City of Northglenn
Main Reservoir - Page 9 - Agency: Lakewood Department of Community Resources
East Reservoir - Page 9 - Agency: Lakewood Department of Community Resources
Smith Reservoir - Page 9 - Agency: Lakewood Department of Community Resources
Kendrick Reservoir - Page 9 - Agency: Foothills Parks & Recreation
Teller Lake - Page 14 - Agency: City of Boulder Open Space

FISH SPECIES ADDITIONS

Barr Lake - Page 4 - Tiger Muskie
Standley Lake - Page 5 - Wiper
Overland Park Pond - Page 8 - Bullhead
Bear Creek Reservoir - Page 9 - Tiger Muskie
Chatfield Reservoir - Page 11 - Walleye
Cherry Creek Reservoir - Page 11 & 12 - Wiper & Tiger Muskie
Quincy Reservoir - Page 12 - Tiger Muskie
Gross Reservoir - Page 15 & 16 - Tiger Muskie
Evergreen Lake - Page 23 - Tiger Muskie

BAG AND POSSESSION LIMITS FOR SPECIFIC FISH
Some waters of the state have more restrictive catch limitations than those listed below. Be sure to check the Colorado fishing regulations before fishing any water.

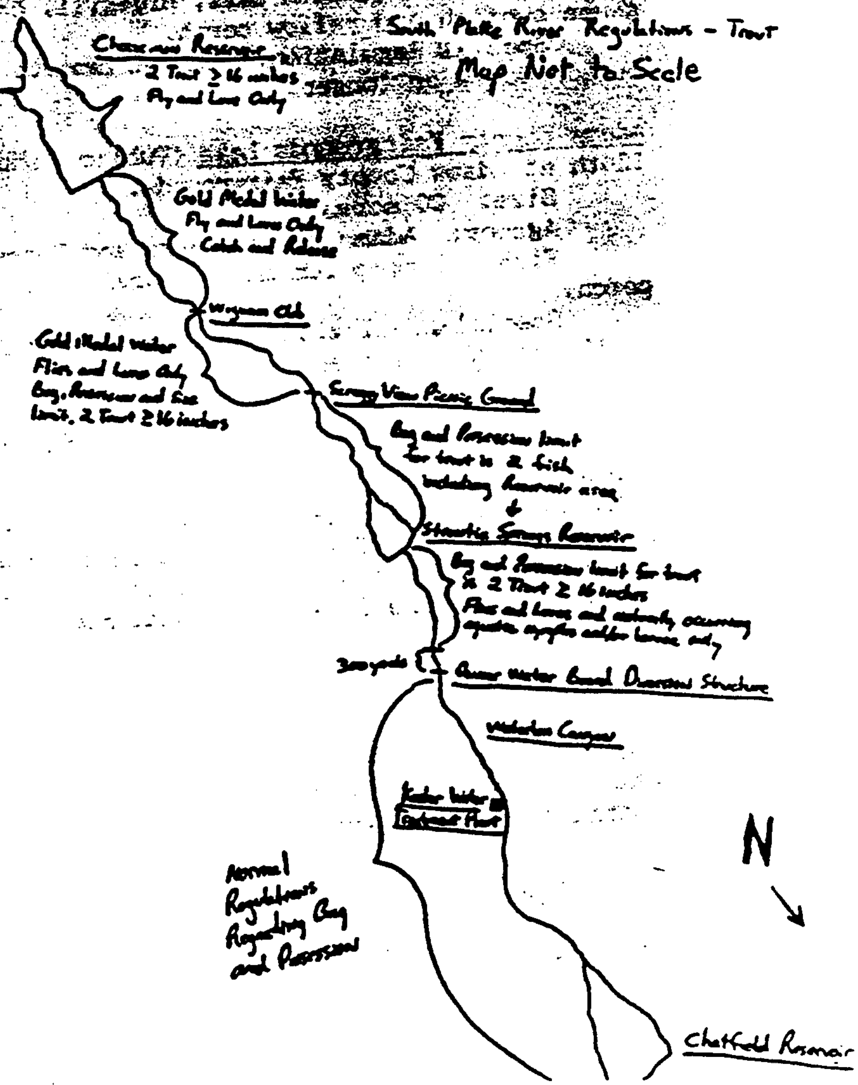
SPECIES		DAILY BAG LIMITS	POSSESSION LIMITS
Rainbow Trout Brown Trout Brook Trout Cutthroat Trout Golden Trout Lake Trout Arctic Char Grayling Coho Salmon	[illegible]	8	8

"In aggregate" means the limit may consist of one species or may be a mixed bag of more than one species.

IN ADDITION TO THE ABOVE DESCRIBED EIGHT FISH DAILY BAG AND POSSESSION LIMITS FOR TROUT, A PERSON MAY TAKE INTO POSSESSION A FULL LIMIT OF EACH OF THE FOLLOWING FISH SPECIES.

Fish	Daily Bag	Possession Limit
Brook Trout [illegible] inches or less	20	20
Kokanee Salmon: Angling, Feb.1-Aug.31	10	10
Snagging or angling, Sept.1-Jan.31	40	40
[illegible]	[illegible]	20
Saugeye	10	10
[illegible]	[illegible]	10
Largemouth Bass	10	10
[illegible]	[illegible]	10
Channel Catfish	10	10
[illegible]	[illegible]	10
White bass or wipers - Arkansas/Republican river drainages (excluding Bonny Reservoir) - 20 fish, in aggregate*, of which no more than 6 can be 20 inches or longer. South Platte Drainage, in aggregate*, 10 fish.		
[illegible]	[illegible]	20
Crappie	20	20
[illegible]	20	20
Northern Pike	20	20
[illegible]	One [illegible] inches or longer	
Crayfish (Crawdads)	No Limit	No Limit
[illegible]	[illegible]	40
Salamander: Aquatic gilled form	120	120
Adult land form	6	6

There are no limits for game fish not listed above (including whitefish).



APPENDIX 6A

DRAFT REPORT

AMBIENT AIR QUALITY MODELING AND HEALTH RISK ASSESSMENT PROTOCOLS, ROCKY MOUNTAIN ARSENAL BASIN "F" LIQUID INCINERATION SYSTEM DESIGN

U.S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
OMAHA, NEBRASKA

Preplanned Remedial Action Contract (PRAC)
Contract No. DACA45-90-D-0015

Task Order No. 1
Document Control No. 3886-44-01-AATT

REVISED DRAFT

AMBIENT AIR QUALITY MODELING AND HEALTH RISK ASSESSMENT PROTOCOLS

FOR

ROCKY MOUNTAIN ARSENAL
BASIN "F" LIQUID INCINERATION SYSTEM DESIGN
Commerce City, CO

Revised 25 November 1990

Prepared by:

ROY F. WESTON, INC.
West Chester, Pennsylvania

AMBIENT AIR QUALITY MODELING AND HEALTH RISK ASSESSMENT PROTOCOLS FOR THE ROCKY MOUNTAIN ARSENAL SUBMERGED QUENCH INCINERATOR

Submitted to:

Prepared for:

Submitted by:

ROY F. WESTON, INC.
Weston Way
West Chester, Pennsylvania 19380

NOVEMBER 1990

W.O.#: 3886-44-01

WESTON

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SECTION 1
INTRODUCTION

The following protocols describe the ambient air quality modeling and health risk assessment approach that will be used to establish numeric emission limits for the Submerged Quench Incinerator (SQI) at the Rocky Mountain Arsenal (RMA) in Denver, Co. The protocol included in this appendix was submitted in final form to the RMA in November of 1990. This protocol should be used only as a general reference to the approach used in this risk assessment. Many of the assumptions, particularly emissions estimates and exposure input parameters, have been extensively revised in early 1991. These revisions, although not included in the protocol, have been fully incorporated into the Final Draft Human Health Risk Assessment (Volumes I, II, and III) submitted June 1991 to RMA. RMA is required to install and operate the SQI to destroy the Basin F liquids currently stored in the three tanks and a double lined pond at the Arsenal. The action is part of the Interim Remedial Action (IRA) selected to treat and dispose of the Basin F liquid. These protocols describe the method to be used to establish stack gas emission limits for the incinerator which correspond to the allowable risk level/hazard index (as identified in the decision document) for the nearest exposed population. The protocols are based on EPA guidelines on air quality modeling and risk assessments and WESTON's experience gained through similar work assignments. The remaining portion of Section 1 presents a brief facility and process description. Section 2 provides a description of the air quality models, input data, and modeling approach to be used and Section 3 provides a description of the health risk assessment approach and methodology for contaminant identification, toxicity assessment, and exposure assessment.

1.1 FACILITY LOCATION AND PROCESS DESCRIPTION

1.1.1 Facility Description

The following facility description is a summary of the information provided in the Final Decision Document for the Basin F Liquid Interim Remedial Action (IRA). Rocky Mountain Arsenal

(RMA) occupies over 17,000 acres (approximately 27 square miles) in Adams County, directly northeast of metropolitan Denver, Colorado. RMA was established in 1942 and has been the site of manufacture of chemical incendiary munitions and chemical munitions demilitarization. Agricultural chemicals including pesticides were manufactured at RMA from 1947 to 1982.

In 1956, an evaporation pond called Basin F was constructed in the northern part of RMA. Basin F had a surface area of 92.7 acres and a capacity of approximately 243 million gallons. From August 1957 until its use was discontinued in December 1981, Basin F was the only evaporative disposal facility in service at RMA.

In 1986, the Department of the Army, Shell Oil Company, and the U.S. Environmental Protection Agency (EPA) Region VIII, agreed that an accelerated remediation be undertaken pursuant to CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) to contain the liquid and contaminated soils in and under Basin F. In a June 5, 1987 report to the court, the Organizations and the State agreed that fourteen interim actions, including the Basin FIRA, were necessary to expedite the cleanup of RMA.

In the first part of Basin F remediation, Basin F liquid was transferred to three lined steel storage tanks and to one double-lined covered pond. Transfer of Basin F liquid to tanks and Pond A for interim storage was initiated in May, 1988 and completed in December 1988. Presently approximately 4 million gallons of liquid are stored in the tank farm and 4.5 million gallons are stored in Pond A.

The Army has selected submerged quench incineration (SQI) to thermally treat 8.5 million gallons of stored liquid from Basin F at Rocky Mountain Arsenal as an Interim Remedial Action. The SQI consists of a feed system to inject the Basin F liquid into the incinerator; the high temperature incinerator with a quench chamber to cool the gases and dissolve the molten salts from combustion; a spray dryer; and associated air pollution control equipment.

1.1.2 Process Description

The submerged quench incineration process will use a vertical downfired liquid incinerator. The liquid to be incinerated would be injected at the top of the furnace into a gas flame. Burning the liquid at high temperature (about 1,900°F) is expected to destroy the organic compounds in Basin F liquid. After incineration, all the combustion products will be forced downward and cooled in a liquid quench tank, to aid in washing out particulates and cleaning the exhaust gases. The high temperatures will melt noncombustible components of the Basin F liquid, producing molten salts which will flow down the walls of the incinerator and also be cooled in a quench chamber. The exhaust gases, which will include a mixture of combustion byproducts and other gases, will be passed through air pollution control devices which include a venture scrubber and a packed tower. The brine from this process will be dried in a spray dryer to produce a salt. The spray dryer exhaust will be fed into a baghouse to control particulate emissions. The baghouse will be exhaust though the stack serving the incinerator.

Operation of the submerged quench incineration process will require the transportation onto the Arsenal of 2,600 cubic yards per year of sodium hydroxide, a caustic compound used in the air pollution control process. The submerged quench incineration process will produce salts, of about 25 percent of the original volume of the Basin F liquid. These salts which contain metals will be disposed of in an off-site hazardous waste landfill.

1.2 PHYSICAL EMISSION CHARACTERISTICS

The physical emission characteristics of the submerged quench incinerator have not been finalized at this time. The incinerator will be designed and operated to meet the RCRA incinerator requirements which are presented in Table 1-1. The trial burn will be required to demonstrate the ability of the incinerator to achieve the performance requirements outlined in the Final Decision Document (May, 1990).

Table 1-1

RCRA Incinerator Requirements[a]

Destruction and Removal Efficiencies	
Dioxin and Dibenzofurans	99.9999%
Polychlorinated Biphenyls	99.9999%
All other Organic Compounds	99.99%
Particulates Emissions	0.08 grains per dry standard cubic ft. @ 7% O_2
Hydrogen Chloride Emissions	1.8 kg/hour 4.0 lb/hour

[a] 40 CFR 264.343 (Performance Standards)

1.3 GOOD ENGINEERING PRACTICE ANALYSIS

Section 123 of the Clean Air Act defines Good Engineering Practice (GEP), with respect to stack heights, as "the height necessary to ensure that emissions from the stack do not result in excessive concentrations of any pollutant in the immediate vicinity of the source as a result of atmospheric downwash, eddies or wakes which may be created by the source itself, nearby structures or nearby terrain obstacles." For this analysis, 40 CFR 51.1(ii) defines nearby as "that distance up to five times the lesser of the height or the (projected) width dimension of a structure, but not greater than 0.8 km .... .

"According to 40 CFR 51.1(ii), GEP stack height means the greater of the following 3 factors.

1. 65 meters, measured from the ground-level elevation at the base of the stack,
2. For stacks in existence after January 12, 1979,

   Hg = H + 1.5 L

   Where:

   Hg = GEP stack height

   H = height of nearby structure(s) measured from the ground level-elevation at the base of the stack.

   L = lesser of height or projected width of nearby structures.

3. The height demonstrated by fluid model or field study which satisfies the definition of GEP in Section 123 of the Clean Air Act.

This GEP stack height analysis will be based upon the EPA (1985) guideline document. The GEP determination will be made for each building, and then the stack will be associated with the nearby building which would result in the greatest GEP. The stack height for the SQI has not been specified at this time. When the stack height is finalized the GEP analysis described above will be performed to determine if building downwash of the stack gases could occur and if building downwash effects will be incorporated into the modeling analyses.

SECTION 2
AIR QUALITY MODELING PROTOCOL

2.1 MODEL SELECTION

Models to be used as input to the exposure assessment and establishment of numerical limits for the incinerator will be EPA-approved UNAMAP Version VI dispersion models and an enhanced version of a UNAMAP model which calculates dry and wet deposition. The procedures used in executing the models will follow those outlined in EPA's Guideline on Air Quality Models (Revised) (1986a, 1987a).

A preliminary review of the geographical setting and a review of the land use pattern near the Rocky Mountain Arsenal was conducted to classify land use for modeling purposes, according to the method of Auer (1978; copy attached). The preliminary review was based on inspection of the typographic maps of the SQI incinerator location out to 3 km. Based on their approximate evaluation, it was determined that greater than 50% of land use was rural. Therefore, models which include rural dispersion coefficients will be used to assess the air quality impact of the facility.

Furthermore, it is expected that there will be no areas near the arsenal where the terrain elevation exceeds stack top. As a result, a USEPA UNAMAP Version VI, rural flat terrain model was selected for the air quality modeling analysis for inhalable concentration calculations and a WESTON modified version of the ISCST model (WESTDEP) was selected for wet, dry, and total deposition calculations. Each of these models are described in the following subsections.

2.1.1 Model for Inhalable Concentrations

The Industrial Source Complex (ISC) model is a steady-state Gaussian plume model which can be sued to assess airborne pollutant concentrations from a wide variety of sources. The ISC

model is part of EPA's UNAMAP VI series models (EPA, 1986b) and consists of a short-term (ISCST) and a long-term (ISCLT) module. It is listed as an EPA-approved "Appendix A" model.

The ISCST model will be used to calculate 1-hour, 3-hour, 8-hour, 24-hour, and annual air concentrations from the facility at receptors no higher than the stack height plus its base elevation. Receptor elevations higher than this are treated by the model as elevations equal to stack height plus base elevation. If the proposed stack height is less than the formula GEP stack height, building wake-effect induced downwash will be accounted for in the model otherwise no downwash effects will be evaluated.

2.1.2 Model for Deposition

The two major mechanisms for the accumulation of materials in surface soils and in surface water are wet and dry deposition. No EPA-approved model or modeling techniques currently exist which appropriately calculate both dry and wet deposition due to source emissions. WESTON has modified the EPA ISCST model to calculate wet, and total dry deposition as suggested in EPA guidance (EPA 1986c). A discussion of the WESTON approach to model these processes is included below.

2.1.2.1 Dry Deposition

Dry deposition is driven by atmospheric processes, the properties of the surfaces upon which materials deposit, and the properties of the particles being deposited. Previous studies of dry deposition have used only gravitational settling velocities to remove particles from the atmosphere. In particular, the EPA's Industrial Source Complex (ISC) model, which contains a gravitational algorithm, has been used in the past to calculate dry deposition. However, this model generally could not account for the properties of the particles deposited, the properties which effect dry deposition, or hourly meteorological effects other than stability.

Work by Sehmel and Hodgsen (1978) has resulted in a parameterization of the dry deposition process which takes more fully into account hourly meteorological conditions (e.g., wind speed, stability, etc.), particle properties (e.g., density, size) and the surface properties (e.g., surface roughness) upon which material is dry deposited.

The basic approach to dry deposition involves calculation of the ambient ground level concentration and the deposition velocity. The deposition flux is given by:

$$-F = V_d \cdot X_i$$

Where:

$-F$ = downward flux of material (dry deposition).

V_d = the deposition velocity.

X_i = is the ambient concentration for pollutant i.

Therefore, if an estimate of the deposition velocity and the ambient concentrations for a pollutant can be made, then the dry deposition flux can be calculated. Ransieri and Croes of the California Air Resources Board (CARB) have developed computer algorithms based on Sehmel and Hodgsen's work which provide hourly values of dry deposition velocity using pre-processed meteorological data which can be obtained using the EPA preprocessor program.

WESTON has modified the EPA UNAMAP Version VI of the ISCST model to incorporate the CARB algorithms to calculate dry deposition and renamed the model WESTDEP. The WESTDEP model calculates hourly ambient ground-level pollutant concentrations as well as hourly deposition velocities to predict the dry deposition flux at each receptor. The model is conservative in that no plume depletion is assumed so that the computed air concentration and deposition rates represent the upper bound limit values. The WESTDEP model allows for building wake effects, terrain adjustments, and incorporates a separate surface roughness coefficient (z_o) for each receptor. Source information required for the model include:

- Source emission parameters:
- Stack height;
- Stack gas velocity;
- Stack gas temperature;
- Pollutant emission rate;
- Building dimensions (for wake effects options);
- Mass particle size distribution.
- Particle density, by size (2 grams/cm^3 will be used for all particle sizes).

The particle size distribution used in the modeling will be based on specification, design and control efficiency of the selected air position control equipment for the incinerator. Meteorological information required is provided by the standard UNAMAP meteorological preprocessor file. In addition, a value for the surface roughness coefficient (Z_o) must be supplied for each receptor. Based upon the typical land use around the RA, a Z_o will be conservatively selected and used in the air quality modeling to represent the impact area. WESTDEP model output includes annual average pollutant concentration at each receptor, total annual dry deposition at each receptor, and average annual dry deposition velocity at each receptor.

2.1.2.2 Wet Deposition

The wet deposition process involves removal of particles via precipitation. Currently, no widely accepted wet deposition models are available. Several studies have developed mechanisms for removal of particles from the atmosphere during precipitation events. These studies assume that particle washout or scavenging is proportional to the mass of the plume exposed to the precipitation event, the intensity and duration of the event, and the size distribution of the particles in the plume, (Radke et al., 1980, Scire and Lurman, 1983).

The scavenging coefficients which have developed in these studies are themselves based on a very limited number of original studies and are generally related to removal of sulfate aerosols. For example, the work of Scier and Lurman is for sulfate and nitrate aerosols. Radke et al.

included measurements in power plant, pulp and paper boilers and volcanic plumes which all have large concentrations of sulfate aerosols. Since these aerosols are hygroscopic, i.e., they have a great affinity for absorbing water in the air, it is likely that scavenging coefficients based on these sources will be higher than for other less water-soluble species such as the pollutants emitted by the facility. Unfortunately, there is no quantifiable data available upon which to base a more reasonable scavenging coefficient. Therefore, the scavenging coefficients used in the WESTDEP model are conservative and provide an upper bound on the amount of wet deposition likely to occur in the area of the RMA.

The EPA (EPA, 1986c) has developed an algorithm which uses scavenging coefficients to calculate wet deposition based on the work of Bowman (1987), and Radke (1980). The algorithm developed includes particle size and rainfall intensity dependent washout coefficients to calculate wet deposition. Table 2-1 includes the scavenging coefficients that will be used in the modeling analysis. The algorithm is based on the mass of pollutants in a vertical column of air which extends from the bottom to the top of the plume. WESTON has integrated this algorithm into the WESTDEP model in order to conservatively calculate wet deposition due to precipitation events.

In order to compute wet deposition, the same information used for the dry deposition calculation is required (i.e., source emission characteristics and hour-by-hour meteorology). In addition, rainfall intensity and rainfall type (e.g., thunderstorm, showers, steady precipitation) is also needed. Furthermore, the WESTDEP model has been modified to compute dry deposition only when no wet deposition i.e., no rainfall is occurring.

The WESTDEP model has been approved for use in the preparation of numerous health risk assessments for hazardous waste incinerators and resource recovery facilities in Kentucky, Maryland, Michigan, Minnesota, New Jersey, Pennsylvania, and Rhode Island.

Therefore, the wet and dry algorithms, which are now a part of the WESTON modified EPA ISC model (WESTDEP) enable WESTON to predict total deposition due to emissions from specific facilities for use in multipathway risk assessments.

2.2 MODEL INPUT DATA

In addition to emission rates and physical emission characteristics of the incinerator other input data are needed to estimate the incremental and overall air quality impact of the incinerator. Specifically, a receptor grid network, meteorological data, and model options are required as input to both the ISC and WESTDEP models.

2.2.1 Receptor Grid Network

A coarse receptor grid network will be established to find the approximate location of maximum estimated air quality impact due to emissions from the facility. From this analysis, the nearest critical receptor(s) can be identified for evaluation in the exposure analysis. A polar coordinate system with a radial every ten degrees beginning with north, centered upon the stack will be used as a basis for receptor deployment for the ISC model application. Receptor points for ISCST will be placed at the following distances from the stack: 2,000m, 2,500m, 3,000m, 4,000m, 5,000m, 6,000m, 8,000m, 10,000m, 12,000m 15,000m, 17,500m, 20,000m, 22,500m and 25,000m. Terrain elevations selected for the receptor grid will be based upon the highest contour between the receptor point and half the distance to any neighboring receptor point. Discrete receptor points will be located at sensitive areas such as hospitals, schools, parks, etc., and along the property line of the RMA. A refined receptor grid with spacing of 100 meters will be used in areas of maximum concentrations identified by the initial course receptor grid. Receptors points will also be placed in 100 meter increments along 10 degree radials from the RMA property line to the first receptor ring. No receptor points will be placed within the RMA property.

Table 2-1

Scavenging Coefficients

Rainfall Intensity	Particle Size Categories (Microns)		
	<2μ	2-10μ	>10μ
Light[a]	0.22×10^{-3}	0.18×10^{-3}	0.969×10^{-2}
Moderate[b]	0.56×10^{-3}	0.893×10^{-3}	0.969×10^{-2}
Heavy[c]	0.146×10^{-2}	0.464×10^{-2}	0.969×10^{-2}

(a) Light is less than 0.1 inches per hour.
(b) Moderate is 0.11-0.3 inches per hour.
(c) Heavy is greater than 0.31 inches per hour.

2.2.2 Meteorological Data

The meteorological data base for the modeling of annual impacts will consist of surface data collected at the Denver Stapleton Airport, for the most recent, available five-year period 1985-1989. The Airport is located approximately 5 miles south of the incinerator.

Selection of the meteorologic data is consistent with the recommendations in Section 6.6 of EPA's On-Site Meteorological Program Guidance for Regulatory Modeling Applications (1987). An annual wind rose for the Airport data showing the prevailing wind directions and wind speed classes is presented in Figure 2-1. Coincident mixing heights will be derived by merging surface temperatures with twice daily upper air data, both obtained from Denver Airport for the period 1985-1989. The raw meteorological surface data and mixing heights will be prepared for input to the ISCST models by using the EPA preprocessor program. Precipitation data from the Denver Airport during the period 1985-1989 will also be merged with the preprocessed data for use in the WESTDEP model for deposition calculations.

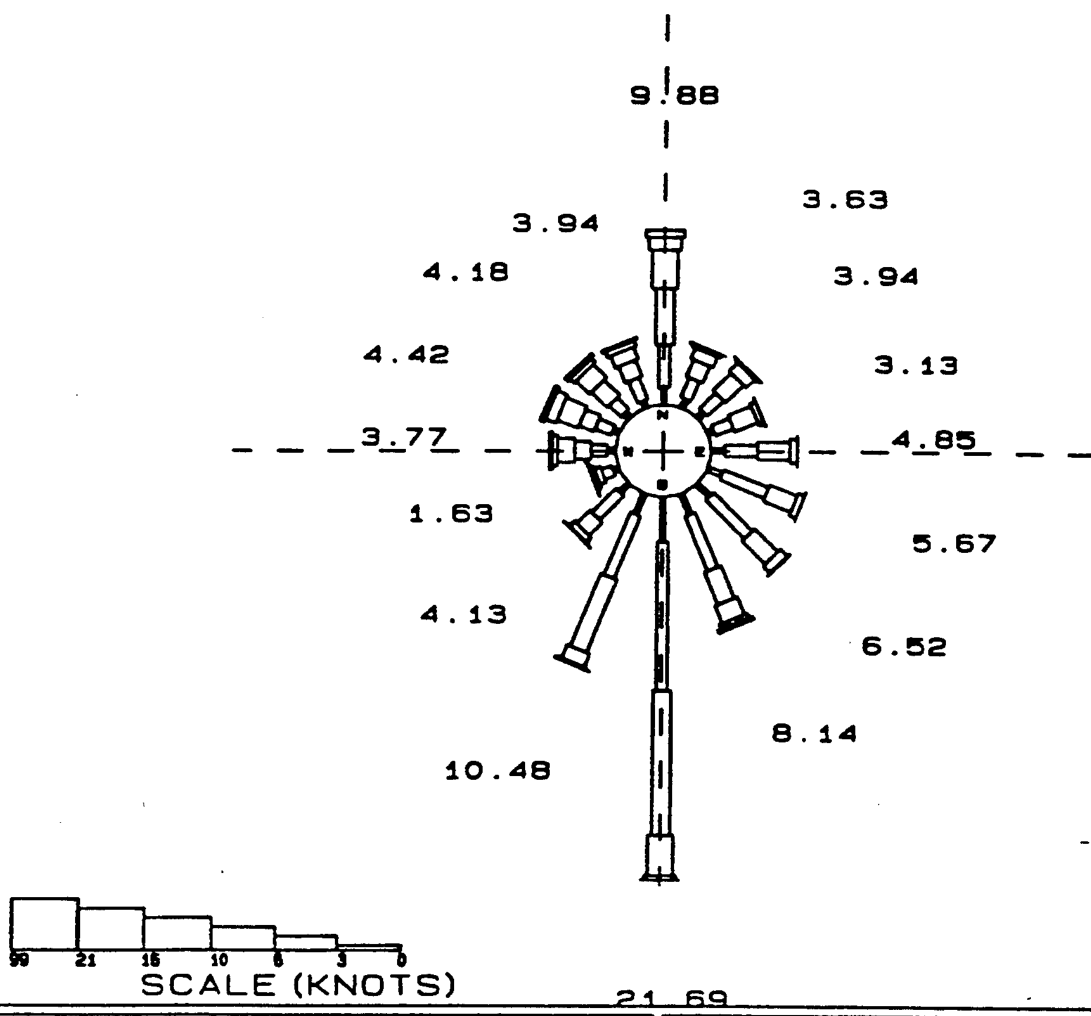
2.2.3 Model Options

The ISCST model has various options to simulate different dispersion conditions for emissions from a stack. The U.S. EPA has recommended (EPA, 1986a) various options to be used in dispersion modeling for regulatory purposes. These recommended regulatory default options, shown in Table 2-2, will be used in the air quality impact analysis for the incinerator.

2.3 AIR QUALITY ANALYSIS

The air quality analysis will be conducted using the models, options, and procedures discussed in previous sections of this protocol. The WESTON model will be employed to estimate annual concentrations, wet/dry and total depositions for each of the five years 1985-1989. Since the expected operational period for the SQI is 18 months, the year with the highest concentration and deposition rates will be used as input to the risk assessment.

DENVER, COLORADO
YEAR: 1988
CALMS INCLUDED



	WIND SPEED (KNOTS) PERCENT OCCURRENCE					
	0-3	3-6	6-10	10-16	16-21	>21
N	0.96	2.47	3.20	2.14	0.72	0.40
NNE	0.61	1.22	1.06	0.66	0.18	0.02
NE	0.45	1.25	1.41	0.66	0.13	0.03
ENE	0.34	1.09	1.34	0.33	0.02	0.00
E	0.73	1.86	1.60	0.43	0.03	0.00
ESE	0.89	2.89	1.66	0.41	0.02	0.00
SE	0.98	3.07	1.86	0.66	0.06	0.00
SSE	1.24	3.39	1.98	1.07	0.28	0.17
S	2.62	8.44	6.17	2.30	0.24	0.02
SSW	1.26	3.86	4.47	0.79	0.09	0.02
SW	0.70	1.92	1.05	0.39	0.06	0.02
WSW	0.34	0.60	0.35	0.19	0.09	0.05
W	0.45	0.94	0.94	0.97	0.26	0.20
WNW	0.39	0.97	0.91	1.29	0.59	0.27
NW	0.38	0.92	1.24	1.08	0.33	0.23
NNW	0.38	1.33	1.01	0.74	0.33	0.14

FIGURE 2-1

Table 2-2

Regulatory Default Options
Proposed for the ISCST Model

- Stack-tip downwash.
- Final plume rise.
- Buoyancy induced dispersion (BID).
- Vertical potential temperature gradients of 0.0, 0.0, 0.0, 0.0, 0.02, 0.035, for stability classes A through F, respectively.
- Automatic treatment of calms.
- Wind profile exponents of 0.07, 0.07, 0.010, 0.15, 0.35, 0.55 for stability classes A through F, respectively.
- Infinite pollutant half-life.

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2.4 REFERENCES

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SECTION 3
RISK ASSESSMENT PROTOCOL

3.1 INTRODUCTION

The objective of the health risk assessment to be conducted by WESTON for Rocky Mountain Arsenal (RMA) is to assist in the establishment of chemical emissions limits for the Basin F Submerged Quench Incinerator (SQI). The resultant emissions limits are to be protective of human health, as stated in the Final Decision Document (May, 1990). The risk characterization results and a discussion of ARARs will be initially presented in the Implementation Document to be submitted to RMA on December 14, 1990, and which will be used to evaluate possible design changes in the SQI. The detailed risk assessment document will be submitted immediately thereafter.

The purpose of this section of the protocol is to present the specific methodology and exposure assumptions to be used by WESTON in the risk assessment. Preliminary data concerning the contaminants of concern are also initially presented. In addition to the Final Decision Document, the approach and methodology draws upon the guidance set forth in the recently revised U.S. EPA Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (EPA, 1989a) and the U.S. EPA Methodology for Assessing Health Risks Associated With Indirect Exposure to Combustor Emissions (EPA, 1990a). These and other pertinent guidance documents are indicated in the appropriate sections, and are listed in the protocol in Subsection 3.7.

A risk assessment for the proposed SQI was previously performed by Woodward-Clyde Consultants (Jan., 1990) to assist in the screening and selection of interim remedial actions (IRAs) as required under CERCLA and the National Contingency Plan. Additionally, on-site (Ebasco Report) and off-site (HLA/ESE Report) human health risk assessments have been performed for RMA with respect to worker and residential exposures, respectively, to existing onsite contamination. To maintain consistency with these studies, WESTON reviewed the data from these previous on-site and off-site evaluations and, where relevant utilized previously

developed exposure assumptions and input parameters, toxicity criteria and background data. These parameters have been appropriately cited in the remainder of this protocol or its attachments.

This risk assessment will be a comprehensive evaluation of both direct and indirect exposure pathways, and will use as the basis for estimating human exposure the results of the air dispersion and deposition modeling, the methods of which are described in Section 2 of this protocol. To be consistent with the most recent EPA guidance (EPA, 1989a; 1990a), WESTON will be considering certain pathways of indirect exposure that were not originally considered in the SQI risk assessment as part of the IRA prepared by Woodward-Clyde Consultants (Jan., 1990). These additional pathways include: breast milk consumption; ingestion of fish from contaminated surface waters; vegetable root uptake of metals and organics; and, beef and dairy cattle exposure with subsequent human consumption of homegrown or commercially-produced beef and cow's milk.

In accordance with the guidance set forth in the Final Decision Document, the risk assessment process will be used to establish emission limits as follows:

- Emission rates (both average and upper 95% confidence limits, where possible) will be determined from evaluation of historical waste stream characterization data, test burn data, and WESTON's hazardous waste incinerator emissions inventory, as described in detail in Section 3.2.

- These emissions data will be used in conjunction with the air modeling, exposure assessment and toxicity assessment results to calculate noncarcinogenic hazard indices and carcinogenic risk for each chemical and pathway in each proposed exposure scenario.

- As directed in the Final Decision Document (p.9-6), cumulative excess carcinogenic risk and noncarcinogenic hazard indices will be determined for each

exposure scenario. Assuming excess cancer risk does not exceed 1E-06, and the noncarcinogenic hazard index does not exceed 1 for the nearest most reasonable maximally-exposed individual, the emission rates for the contaminants of concern will be considered protective of human health. WESTON has developed four exposure scenarios, described in detail in Section 3.4.1, which represent reasonable maximally-exposed individuals in the vicinity of the facility. The facility is assumed to operate for two years.

- Should the cumulative cancer risk or noncarcinogenic hazard index exceed the limits described above for the most reasonable maximally-exposed individual, each contaminant and pathway assessed in that scenario will be evaluated to develop a profile of the major contributor(s) to risk. A report summarizing these findings will be presented to the appropriate agencies, as outlined in the Final Decision Document, to determine whether a change in the design of the treatment system is necessary.

The protocol is divided into four sections:

1. Contaminant Identification, Selection and Emission Rate Determination (Section 3.2)

2. Toxicity Assessment (Section 3.3)

3. Exposure Assessment (Section 3.4)

4. Risk Characterization (Section 3.5)

These sections of the protocol will correspond to the general format to be used in the final risk assessment document. For the final document, detailed calculations and supporting information that are applicable to the material presented in each of the sections of the final risk assessment document will be included in corresponding appendices.

3.2 CONTAMINANT IDENTIFICATION, SELECTION AND EMISSION RATE DETERMINATION

Initial identification of potentially emitted contaminants, and estimation of their emission rates will be based on an analysis of the composition of the waste stream and its theoretical products of incomplete combustion, valid test burn data, and comparison with WESTON's hazardous waste incinerator emissions database. This approach should be consistent with the Final Decision Document and yield a very conservative estimate of the emitted chemicals and their likely emission rates. This information will be supplemented or verified by additional Basin F liquid analyses being conducted currently, if the analytical results are available when the contaminant identification phase of the risk assessment is performed.

3.2.1 Contaminant Identification

Four groups of pollutants and their respective emission rates will be developed. These chemicals are generally categorized as principal organic hazardous constituents (POHCs), products of incomplete combustion (PICs), metals, and criteria pollutants (gases, particulates, and acid gases). The detailed lists of initially identified potential pollutants and emission rates are presented in Tables 1 and 2 (Appendix A). The remainder of this section discusses the methodology used for selecting the chemicals of concern.

3.2.1.1 Analysis of Waste Stream Composition

The following methodology was used to evaluate the waste stream composition for the Basin F liquid material at the RMA:

- The historical characterization data from 1978 through 1988 for the basin and the recent WESTON analyses for the pond and for the tanks were converted to a common basis of mg/l. (This involved a density correction considering the 1.24

g/ml density of the waste for the historical data that had been reported as ppm or ppb).

- The average and maximum of the reported values for each data source were taken for the values from the basin, pond and tank, each taken separately. (If a range was reported for a particular source of analyses, the midpoint of the range was assumed to represent the average and the upper range to represent the maximum of the data set).

- The maximum of the average values of the basin, pond and tank analyses were calculated, as well as the maximum of the maximum values.

- The maximum of the average and maximum of the maximum values were summed for all compounds (organics and metals).

- Because the total of the maximums of the maximum values was about 1 million mg/l, or about 100%, this approach was considered too overly conservative, even for risk assessment purposes. The total of maximums of the averages, however, was about 640,000 mg/l (about the same value as the portion of the waste stream that is not water).

Therefore, the maximums of the average values from each of the basin, pond, and tanks were taken as a reasonable worst case estimate of the composition of the waste stream. These values were then converted to tons of component per year for the design incinerator capacity of 10,325 lb/hr. These data were used by Dr. Barry Dellinger to predict the PICs and POHCs as discussed in more detail below.

3.2.1.2 Evaluation of Test Burn Data

Emissions testing results conducted during the test burns of Basin F waste performed by T-Thermal (August, 1990) were evaluated by the WESTON Air Permitting and Engineering staff. A number of the test runs were considered unacceptable for emissions estimation because of feed clogging followed by rapping or oxygen blasts into the feed nozzles. Two dioxin/furan runs, and one metals run were considered valid. The remaining runs have been discarded for evaluation purposes.

Compared to other hazardous waste incinerators, the dioxin/furan TEF for the two runs appears relatively small (0.06 ng/Nm3) compared to WESTON's emissions database values. However, the risk this poses cannot as yet be determined. For the risk analysis base case (i.e., average conditions), we will use the average of the two test burn runs; for the sensitivity case (i.e., upper bound conditions), we will use the upper 95% confidence limit of the WESTON database for hazardous waste incinerators.

The test burn data for the one acceptable run for metals compare well with the emission estimates based on the waste stream data (average of the maximums) and removal efficiencies published by the U.S. EPA for hazardous waste incinerators. Therefore, we will use the maximum of these two data sets for the base case. U.S. EPA Tier I and Tier II guidance values, based on the "maximum of the maximums" of the waste stream data and emission test runs from the test burn will be considered in the sensitivity analysis.

For pesticides and PCBs, we will use Dr. Dellinger's POHC and PIC data. These potential pollutants were not detected during the test burn emission testing

3.2.1.3 Key Organic Pollutants in the Waste Profile

Organic compounds were identified either as POHCs from an analysis of the waste stream composition (Section 3.2.1.1) or from the analysis of PICs resulting form combustion of the

POHCs (Section 3.2.1.4). Toluene was predicted to be the most difficult compound to destroy, and, therefore it was used to normalize destruction removal efficiency (DRE) for all POHCs by assuming toluene would be destroyed with a 99.99% DRE as verified by a trial burn. Historical data indicate that organics present in the waste stream include volatiles, semi-volatiles, and pesticides. Dioxins and furans, determined from an evaluation of the test burn data discussed above, are listed separately and are expressed as toxic equivalents based on the most recent U.S. EPA guidance (EPA, 1989b).

3.2.1.4 Products of Incomplete Combustion (With or Without Precursors)

Products of incomplete combustion (PICs) are organic compounds present in emissions from an incinerator and which are formed from the thermal breakdown of chemicals present in the waste stream, reformation reactions, or some other process subsequent to incineration (Trenholm and Hathaway, 1984; Oppelt, 1987). Specific PICs, with or without precursors, have been identified and their emission rates estimated by Dr. Barry Dellinger, who has been subcontracted for this effort.

3.2.1.5 Metals

Identification of metals and determination of their emission rates will be based on waste stream characteristics, test burn data and the U.S. EPA guidance document as discussed under Section 3.2.1.2.

3.2.1.6 Criteria Pollutants and Acid Gases

Selected criteria pollutants (particulate matter, sulfur dioxide, nitrogen dioxide, and carbon monoxide) and acid gases (primarily hydrogen chloride and hydrogen fluoride) will be evaluated both for potential acute and chronic health effects by the inhalation pathway. Their emissions rates were determined from test burn data, vendor guarantees and WESTON's hazardous waste emissions inventory database.

3.2.2 Emission Rates

Table 1 of Appendix A summarizes the initial list of emitted organic and inorganic chemicals with estimated emissions rates. Base case emissions rates are conservatively high estimates of the emissions which would be expected during the course of normal operation. Their methods of determination are footnoted in the table. Sensitivity case emissions rates represent upper bound or maximum worst case expected rates. Refer to the footnotes in Table 1 for specific methods of determination. Criteria pollutants, gases, and particulates are presented in detail in Table 2.

3.2.3 Final Selection of Contaminants of Concern

The final contaminants of concern will be selected from the initial list for each medium of potential exposure (air, soil, surface water) based on various conservative criteria discussed in detail below. The purpose of this part of the evaluation is to eliminate from the large list of chemicals those that will not likely.

3.2.3.1 Air

All contaminants, both carcinogens and noncarcinogens, will be evaluated in the air pathway, including the criteria pollutant gases and particulates.

3.2.3.2 Soil

All carcinogens (by the oral route) will be retained for final evaluation in all soil pathways. Volatile organics (VOCs) will be excluded from soil pathways based on the following rationale:

- VOCs are likely to be emitted as vapors

- VOCs are unlikely to be deposited in soils following their emission

- VOCs are unlikely to be persistent in soil, if deposited

For purposes of this screening procedure, a VOC is defined as any chemical (carcinogen or noncarcinogen) with a vapor pressure greater than 1E+02 mm Hg and/or Henry's Law constants greater than 1E-03 atm-m^3/mol (Lyman, et al., 1982). The vapor pressure criterion was derived from inspection of the range of vapor pressures of chemicals that EPA classifies as volatiles (EPA, 1986).

Metals (except oral carcinogens) were screened based on comparison with regional background metals concentrations. Background data were obtained from data WESTON gathered for Rocky Flats (WESTON, 1989). Metals were excluded from further analysis through soil pathways if their predicted maximum total deposition at the points of exposure (refer to Section 3.4.1 for specific locations of reasonable maximally-exposed individuals) were greater than or equal to 1 percent of the mean background concentrations for the respective metal.

3.2.3.3 Surface Water

Land use evaluation and the deposition modeling isopleths revealed that Engineer's Lake, a designated manmade recreational fishing area (refer to Section 3.4 for more detail) was impacted by facility emissions. Contaminants of concern were evaluated for consideration in the surface water pathway (i.e., fish consumption) based on several criteria:

- all oral carcinogens will be included in the final surface water pathway evaluation

- VOCs were excluded from this pathway based on the same rationale as previously discussed for soils

- a modified Tier I analysis was performed to evaluate the remaining chemicals for possible exclusion from the surface water pathway. The basis of this screening analysis is to estimate a highly conservative concentration of the chemical

contaminants in the impacted surface water body and compare this to the Ambient Water Quality Criteria (AWQC) for fish consumption by humans. If a chemical had no designated AWQC, it was excluded from this analysis, and will be included in the more detailed surface water pathway evaluation in the actual risk assessment. The total areal deposition for the 32 acre watershed of Engineer's Lake was determined from the modeled isopleths. Lakewater concentrations for each chemical were determined by dividing the total amount deposited in the lake by the total volume of the lake. It was conservatively assumed that the lake had a 0.5 year hydraulic retention time and that all chemicals adsorbed to soil runoff was desorbed into the water. Table 3 in Appendix A shows the results of this analysis. It was concluded that the nine chemicals evaluated in this screen could be excluded from further evaluation based on the criterion that their conservatively predicted water concentrations were less than 10 percent of their respective AWQCs.

3.3 TOXICITY ASSESSMENT

The Integrated Risk Information System (IRIS) computer data base (EPA, 1990b) will be referred to for the most recent U.S. EPA reference doses and cancer potency factors. Other EPA sources, including EPA's quarterly Health Effects Assessment Summary Tables (EPA, 1990c), will also be used for those chemicals for which toxicity values are unavailable on IRIS.

For those chemicals for which EPA-derived potency factors or reference doses are unavailable, toxicity values will be derived from health-based criteria or toxicity data. Derived toxicity values published in the on-post and off-post exposure assessments will be used if possible. All approaches for the derivation of reference doses or cancer potency factors will be fully discussed in the risk assessment. The use of derived toxicity values and the methods by which they will be derived will be subject to the review of U.S. EPA Region VIII and RMA. Tables 4A and $b in Appendix A list the chemicals of concern with their carcinogenic slope factors and reference loses, respectively.

To evaluate dioxins and furans, WESTON will follow, if applicable, the guidelines set forth in the Interim Procedures for Estimating Risks Associated with Mixtures of CDDs and CDFs (EPA, 1989b).

3.4 EXPOSURE ASSESSMENT

3.4.1 Exposure Scenarios

The exposure scenarios have been evaluated based upon the air dispersion and deposition modeling results. Theoretically, to determine emissions limits, it is necessary to evaluate only one scenario, the most reasonable maximally-exposed individual (RMEI). Reasonable maximum exposure is defined by the U.S. EPA as "the highest exposure that is reasonably expected to occur at a site" (EPA, 1989a). However, the RMEI cannot always be determined based on the modeling results alone. Therefore, it is recommended that several exposure scenarios be evaluated in the risk assessment. The scenario ultimately resulting in the greatest risk (i.e., most exposed), as directed in the Final Decision Document, will be used to assess numerical chemical emissions limits.

Based on available information regarding current off-site and on-site land usage, and the results of the air deposition modeling, four potential RMEIs have been identified. The scenarios presented below represent present use conditions. No future use scenarios were included since hypothetical exposures in this case would not likely exceed any present use exposures; this is based on the assessment that pathways of exposure and areas of maximum impact of emissions would not be different from any present use condition. The four potential RMEIs are:

- An individual currently living within the residential area where total deposition (dry plus wet) is maximal (i.e., just south of the property fenceline).

- An individual currently living within the residential area where dry deposition will be maximal (i.e., just north of fenceline).

- An individual currently living on a local cattle farm where total deposition is highest for that land use (i.e., just northwest of site).

- A maintenance worker on the site who is exposed to an area weighted air concentration and wet/dry deposition as determined from the modeling results.

The respective locations of these RMEIs are indicated on the site diagram in Appendix A (Figure 1). The isopleths developed for the air modeling are not provided here but will presented in the final report. Note that all residential exposure scenarios include a fish consumption pathway based on the finding that Engineer's Lake, a recreational fishing area, is impacted by the deposition analysis. The Lake is located just west of RMA near Adams City.

Subsections 3.4.2 through 3.4.4 detail the specific equations or approaches for determining media concentrations, and the exposure algorithms and input parameters that will be employed by WESTON in determining estimated daily intakes (i.e., doses) of each of the pollutants. When available, site-specific or more recently developed input factors (e.g., ingestion rates) will be used in preference to the factors presented in the protocol. Table 5 of Appendix A is a summary of the key input parameters for air and soil pathways which has been developed in consultation with Dr. Chris Weis of EPA VIII and following a review of the offsite and onsite exposure assessments performed previously for RMA. Additional parameters are discussed with the algorithms in Sections 3.2.2 through 3.2.4. Depending on the results of the evaluation of local land and water usages and final contaminant pathways analysis, it is possible that some of these algorithms will not be included. The exposure algorithms presented in these subsections estimate daily exposure doses based on expected media concentrations determined through the dispersion and deposition modeling results. Adjustments to lifetime exposure doses will be determined in the risk characterization section. Section 3.5 discusses this in more detail.

A groundwater exposure pathway has not been included in this protocol. It has been WESTON's experience that groundwater contamination from incinerator facility emissions is minimal and makes no significant contribution to total risk. Current EPA guidance for assessing health risks

associated with combustor emissions indicates that the evaluation of the groundwater pathway is unnecessary due to limited potential for groundwater contamination (EPA, 1990a). However, should groundwater recharge patterns and private well use be significant factors at the proposed site, this pathway can be further evaluated.

3.4.2 Inhalation Exposure

3.4.2.1 Air Concentrations of Pollutants

The concentrations of pollutants in the ambient air will be determined based on the dispersion modeling results.

3.4.2.2 Exposure through Inhalation

$$\underset{(mg/kg/day)}{\text{Dose From Inhalation}} = \underset{(mg/m^3)}{\text{Ambient Air Concentration}} \times \underset{(m^3/day)}{\text{Respiration Rate}} \times \frac{1}{\underset{(kg)}{\text{Body Weight}}}$$

Where:

- Respiration Rate = 20 m^3/day - adult (EPA, 1989c), 10 m^3/day - child (USNRC, 1977), 3.8 m^3/day - infant (NCRP, 1984)

- Body Weight = 70 kg - adult, 15.5 kg - child, 9 kg - infant (0-1 yr old) (EPA, 1989c; Ebasco, 1989)

3.4.3 Ingestion Exposure

3.4.3.1 Soil Concentrations of Pollutants

Contaminants with no expected significant degradation:

$$\text{Maximum Contaminant Concentration in Soil (mg/kg)} = \frac{\text{Total Deposition Rate } (g/m^2/\text{year}) \times \frac{10^3 \text{ mg}}{\text{g}} \times \text{Expected Facility Life (years)}}{\text{Soil Density } (kg/m^3) \times \text{Soil Mixing Depth (m)}}$$

Where:

- Expected Facility Life = 2 years
- Soil Density = site specific
- Soil Mixing Depth = 0.1 m (for untilled soil) (EPA, 1990a)
  = 0.2 m (for tilled soil) (EPA, 1990a)

Contaminants with expected significant degradation:

$$\text{Maximum Contaminant Concentration in Soil (mg/kg)} = \frac{1-e^{(-kt)} \times \text{Total Deposition Rate } (g/m^2/\text{year}) \times \frac{10^3 \text{ mg}}{\text{g}}}{k \times \text{Soil Density } (kg/m^3) \times \text{Soil Mixing Depth (m)}}$$

Where:

k = Decay Coefficient (yr^{-1}), chemical specific

t = Expected Facility Life = 2 years*

*An average concentration is also calculated for the contaminants with expected loss using a computerized model which takes into account daily degradation over 70 years.

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3.4.3.2 Exposure from Soil/Dust Ingestion

$$\text{Contaminant Dose from Soil/Dust (mg/kg)} = \frac{\text{Contaminant Concentration in Soil (kg/day)} \times \text{Soil Ingestion Rate (mg/kg)} + \text{Dust Conc Rate} \times \text{Dust Ingestion Rate (kg/day)}}{\text{Body Weight (kg)}}$$

Dust concentrations are assumed to be equal to the 0.1 m mixing depth soil concentrations.

Where:

- Annual average dust ingestion rate = 4.26E-06 kg/day - adult (EPA, 1989c).
- Annual average soil ingestion rate = 5.7E-05 kg/day - adult (EPA, 1989c).
- Soil/Dust Ingestion Rate = 1.65 E-04 kg/day - child (EPA, 1989c).
- Body Weight = 70 kg - adult, 15.5 kg - child (EPA, 1989c).

3.4.3.3 Garden Produce Ingestion

$$\text{Contaminant Concentration in/on Produce (mg/kg)} = \text{Contaminant Concentration in Soil (mg/kg)} \times \text{Root Uptake Factor} + \text{Dry Deposition Rate (g/m}^2\text{/year)} \times \text{Vertical Surface Deposition Factor (m}^2\text{sec/kg)} \times \frac{\text{g}}{10^3\ \text{mg}} \times \frac{3.15\text{E+07 sec}}{\text{yr}}$$

For root vegetables, the second term of this equation (i.e., the contribution of contaminant deposition on the plant) drops out. The second term also drops out when calculating the contaminant concentrations in/on leafy vegetables and garden fruits during the years after the facility is closed.

Where:

- Soil concentration is calculated with an assumed mixing depth of 20 cm (EPA, 1990a).

- Root Uptake Factor - chemical specific (inorganics: Baes et al., 1984; organics calculated based on Briggs et al., 1982 (root vegetables) and Travis and Arms, 1988).

- Vertical Surface Deposition Factor $= \dfrac{r\,(1-e^{-kt})}{Yk}$

r	=	Interception fraction of the plant (unitless) (Baes et al., 1984).
k	=	Total rate constant for degradation process (seconds^{-1}) (Baes et al., 1984).
t	=	Growing Time (seconds)
y	=	Plant Yield (wet weight) (kg/m^2)

$$\begin{aligned}
\text{Contaminant Dose from Produce Ingestion (mg/kg/day)} = {} & \text{Contaminant Concentration in Leafy Vegetables (mg/kg)} \times \text{Leafy Vegetable Consumption Rate (kg/day)} \times \text{Fractions Homegrown} \; + \\
& \text{Contaminant Concentration in Root Vegetables (mg/kg)} \times \text{Root Vegetable Consumption Rate (kg/day)} \times \text{Fraction Homegrown} \; + \\
& \text{Contaminant Concentration in Garden Fruits (mg/kg)} \times \text{Garden Fruit Consumption Rate (kg/day)} \\
& \times \text{Fraction Homegrown} \times \frac{1}{\text{Body Weight (kg)}}
\end{aligned}$$

Where:

- Consumption Rates in wet weight (calculated from EPA, 1986 and Baes et al., 1984)

  leafy vegetables = 4.82E-02 kg/day - adult, 9.64E-03 kg/day - child.

  root vegetables = 1.49E-02 kg/day - adult, 6.26E-03 kg/day - child.

  garden fruits = 8.61E-02 kg/day - adult, 3.34E-02 kg/day - child.

- Body Weight = 70 kg - adult, 15 kg - child (EPA, 1989c).

- Fraction Homegrown (rural) = 0.596 (EPA, 1986).

To the extent possible, local consumption rates and homegrown fractions will be further investigated as part of the land use analysis.

3.4.3.4 Surface Water Concentrations of Pollutants

If the surface water pathway is determined to be a key exposure route, surface water concentrations will be determined using a Tier 2 analysis (EPA, 1990a). If requested, the details of the surface water model will be provided in a supplementary memorandum.

3.4.3.5 Drinking Water Ingestion

$$\text{Contaminant Dose from Surface Water Ingestion (mg/kg/day)} = \text{Estimated Surface Water Concentration (mg/L)} \times \text{Surface Water Consumption Rate (L/day)} \times \frac{1}{\text{Body Weight (kg)}}$$

Where:

- Surface Water Consumption Rate = 1.4 L/day - adult, 1 L/day - child (EPA, 1989c)

- Body Weight = 70 kg - adult, 15 kg - child (EPA, 1989c).

3.4.3.6 Fish Ingestion

$$\text{Contaminant Concentration in Fish (mg/kg)} = \text{Contaminant Concentration in Water (mg/L)} \times \text{Adjusted Bioconcentration Factor (L/kg)}$$

Where:

- Adjusted Bioconcentration Factor: compound specific, adjusted to account for difference in lipid content in test and study organism (if information is available) =

  $$\text{Bioconcentration Factor} \times \frac{\text{LC Study}}{\text{LC Test}}$$

Where:

- LC study = Lipid concentration in study organism
- LC test = Lipid concentration in test organism

If data are available, an adjustment of the predicted contaminant concentration in the whole body of the fish to a concentration in the edible portion of the fish will be made.

$$\text{Contaminant Dose from Fish Ingestion (mg/kg/day)} = \text{Contaminant Concentration in Fish (mg/kg)} \times \text{Daily Fish Consumption Rate (kg/day)} \times \frac{1}{\text{Body Weight (kg)}}$$

- Fish Consumption Rate = 0.030 kg/day - adult (EPA, 1989c), 0.015 kg/day - child.
- Body Weight = 70 kg - adult, 15 kg - child (EPA, 1989c).

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3.4.3.7 Ingestion of Meat and Milk

$$\text{Animal Feed (Pasture Grass, Hay, Grain, and Corn Silage) Contaminant Concentration (mg/kg)} = \text{Contaminant Concentration in Soil (mg/kg)} \times \text{Root Uptake Factor} + \text{Dry Deposition Rate (g/m}^2\text{/yr)}$$

$$\times \text{Vertical Surface Deposition Factor (m}^2\text{sec/kg)} \times \frac{1{,}000 \text{ mg}}{\text{g}} \times \frac{\text{yr}}{3.15\text{E+07 sec}}$$

Only the first term of the equation applies for calculating contaminant concentration in grain. The second term also drops out when calculating contaminant concentrations in/on other animal feed during the years after the facility is closed.

Where:

- Vertical Surface Deposition Factor (see Section 3.2.3).

- Root Uptake Factor - chemical specific.

$$\text{Contaminant Concentration in Animal Diet (mg/kg)} = \frac{\text{Contaminant Concentration in Animal Feed Concentration (mg/kg)} \times \text{Daily Intake of Feed (kg/day)} + \text{Contaminant Concentration in Soil (mg/kg)} \times \text{Daily Intake of Soil (kg/day)}}{\text{Daily Intake of Feed (kg/day)} + \text{Daily Intake of Soil (kg/day)}}$$

Where:

- Daily Intake

  Feed = dependent on area-specific farming practices and type of cattle

  Soil = 2 percent of grazing diet (Fries, 1986)

- Soil Concentration - Calculated using a 0.1 m mixing depth for untilled soil (e.g., pasture grass) and a 0.20 m mixing depth for tilled soil (e.g., corn, grain, hay). (EPA, 1990a).

$$\text{Contaminant Concentration In Animal Product (mg/kg)} = \text{Animal Intake (mg/kg)} \times \text{Tissue Uptake Factor (day/kg)} \times \text{Total Feed Intake* (kg/day)}$$

- Tissue Uptake Factor - contaminant specific (Baes et al., 1984; Fries, 1986; Travis et al., 1988).

* Total feed intake is not used in determining dioxin concentrations in animal products and the dioxin tissue uptake factor is unitless.

$$\text{Contaminant Dose from Animal Product Ingestion} = \frac{\text{Contaminant Concentration in Animal Product (mg/kg)} \times \text{Product Consumption Rate (kg/day)} \times \text{Fraction Homegrown Product}}{\text{Body Weight (kg)}}$$

Where:

- Product Consumption Rates:

  Beef = 0.037 kg/day - child (Pao et al., 1982), 0.067 kg/day - adult (Fries, 1986).

  Beef fat = 0.009 kg/day - child (EPA, 1986), 0.015 kg/day - adult (Fries, 1986).

  Milk = 0.39 kg/day - child (Pao et al., 1982), 0.305 kg/day - adult (Fries, 1986).

  Milk fat = 0.016 kg/day - child (EPA, 1986), 0.01 kg/day - adult (Fries, 1986)

- Fraction Homegrown or obtained from a local source (rural)

  Beef = 0.44 (EPA, 1986)

  Milk = 0.3994 (EPA, 1986)

- Body Weight = 70 kg - adult, 15 kg - child (EPA, 1989c).

3.4.3.8 Breast Milk Ingestion

$$\text{Breast Milk Concentration (mg/kg)} = \text{Sum of Contaminant Doses to Mother (mg/kg/day)} \times \text{Breast Milk Transfer Factor (day)}$$

Where:

- Sum of Contaminant Doses: Total dose through all exposure routes
- Breast Milk Transfer Factor: chemical specific (Smith, 1987; Travis et al., 1988)

The breast milk pathway will be evaluated for organic contaminants only due to insufficient information regarding breast milk transfer factors (based on estimated daily intakes) for metals in human milk.

$$\text{Infant Contaminant Dose (mg/kg/day)} = \frac{\text{Contaminant Concentration in Breast Milk (mg/kg)} \times \text{Milk Ingestion Rate (kg/day)}}{\text{Infant Body Weight (kg)}}$$

Where:

- Milk Ingestion Rate = 0.8 kg/day (Smith, 1987)
- Infant Body Weight (0-1 yr old) = 9 kg (EPA, 1989c)

3.4.4 Dermal Exposure

$$\text{Dose From Dermal Contact (mg/kg/day)} = \text{Contaminant Concentration in Soil (mg/kg)} \times \text{Exposed Skin Surface Area (cm}^2\text{)} \times \text{Soil Adherence Factor (mg/cm}^2\text{/event)} \times \text{Dermal Absorption Factor}$$

$$\times \begin{array}{l}\text{Number of Exposure}\\ \text{Events per Week}\\ \text{(events/wk)}\end{array} \times \frac{\text{kg}}{10^6\ \text{mg}} \times \frac{\text{week}}{7\ \text{days}} \times \frac{1}{\text{Body Weight (kg)}}$$

Where:

- Exposed Skin Surface (arm and hand) Area: 3190 cm^2 - adult, 1,480 cm^2 - child (Anderson et al., 1985).

- Soil Adherence Factor - 1.45 mg/cm^2 (EPA, 1989a).

- Dermal Absorption Factor - chemical specific (based on Skog and Wahlberg, 1964; Poiger and Schlatter, 1980).

- Body Weight = 70 kg - adult, 15 kg - child (EPA, 1989cc).

3.5 RISK CHARACTERIZATION

3.5.1 Evaluation of Risk

3.5.1.1 Noncarcinogenic Risk

Noncarcinogenic risk will initially be evaluated by comparing contaminant doses to chronic reference doses. The contaminant dose: reference dose ratios (i.e., hazard quotients) will be summed to calculate the total chronic hazard index. Separate hazard indices will be calculated for the adult, child, and infant. If a chronic hazard index exceeds one, the potential for acute health effects will also be determined, by comparing the contaminant doses to available or derived short-term toxicity values.

3.5.1.2 Carcinogenic Risk

The carcinogenic risk posed by each contaminant through each exposure route will be calculated using the following equation:

$$\text{Cancer Risk} = \text{Contaminant Dose (mg/kg/day)} \times \text{Carcinogenic Potency Factor (mg/kg/day)}^{-1} \times \text{Exposure Duration Adjustment}$$

The exposure duration adjustment takes into account the length of exposure, in effect averaging the calculated daily contaminant dose over a 70-year lifetime. The total risk posed by each contaminant will be calculated by adding the risks posed by the contaminant through all exposure routes. The lifetime incremental cancer risk posed by all contaminants will be estimated by summing the risks posed by all contaminants through all exposure routes.

3.5.2 Uncertainty Analysis

All key assumptions and uncertainties and their potential effects on the risk estimates presented in the risk characterization will be summarized. A quantitative sensitivity analysis will be performed for some of the assumptions that are indicated to have the greatest impact on the calculation of total risk.

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APPENDIX A

PRELIMINARY DATA AND SUPPORTING DOCUMENTATION
FOR HEALTH RISK ASSESSMENT PROTOCOL

APPENDIX A

PRELIMINARY DATA AND SUPPORTING DOCUMENTATION
FOR HEALTH RISK ASSESSMENT PROTOCOL

TABLE 1. **EMISSION RATES FOR ROCKY MOUNTAIN ARSENAL BASIN F WASTE SUBMERGED QUENCH INCINERATOR**

Category/ Pollutant	Base Case (a) (ton/yr)	Base Case (a) (lb/hr)	Base Case (a) (g/sec) (c)	Sensitivity Case (b) (ton/yr)	Sensitivity Case (b) (lb/hr)	Sensitivity Case (b) (g/sec) (c)
Dioxins/Furans						
U.S. EPA TEF	4.16E-09	1.19E-09	1.50E-10	6.63E-08	1.90E-08	2.39E-09
Metals						
Aluminum	1.80E-02	5.15E-03	6.49E-04	2.50E-02	7.14E-03	8.99E-04
Antimony	6.34E-04	1.81E-04	2.28E-05	1.35E-03	3.85E-04	4.85E-05
Arsenic	3.59E-03	1.03E-03	1.29E-04	8.67E-03	2.48E-03	3.12E-04
Barium	8.79E-04	2.51E-04	3.16E-05	8.79E-04	2.51E-04	3.16E-05
Beryllium	3.66E-05	1.05E-05	1.32E-06	7.20E-05	2.06E-05	2.59E-06
Boron	2.68E-02	7.65E-03	9.63E-04	3.63E-02	1.04E-02	1.31E-03
Cadmium	5.62E-04	1.61E-04	2.02E-05	2.17E-03	6.20E-04	7.81E-05
Calcium	1.54E-01	4.39E-02	5.53E-03	2.93E-01	8.36E-02	1.05E-02
Chromium	2.47E-04	7.05E-05	8.88E-06	3.32E-04	9.49E-05	1.20E-05
Cobalt	7.89E-04	2.25E-04	2.84E-05	8.13E-04	2.32E-04	2.93E-05
Copper	3.35E+00	9.59E-01	1.21E-01	6.35E+00	1.82E+00	2.29E-01
Iron	4.77E-02	1.36E-02	1.72E-03	8.13E-02	2.32E-02	2.93E-03
Lead	1.12E-03	3.21E-04	4.05E-05	2.17E-03	6.20E-04	7.81E-05
Lithium	1.10E-04	3.14E-05	3.96E-06	2.07E-04	5.92E-05	7.45E-06
Magnesium	1.43E-01	4.08E-02	5.14E-03	2.39E-01	6.81E-02	8.59E-03
Manganese	6.16E-03	1.76E-03	2.22E-04	6.93E-03	1.98E-03	2.50E-04
Mercury	9.93E-04	2.84E-04	3.57E-05	1.49E-03	4.25E-04	5.35E-05
Molybdenum	1.10E-02	3.15E-03	3.97E-04	1.14E-02	3.25E-03	4.09E-04
Nickel	2.86E-02	8.18E-03	1.03E-03	2.97E-02	8.49E-03	1.07E-03
Potassium	1.14E+00	3.25E-01	4.09E-02	2.54E+00	7.24E-01	9.13E-02
Selenium	9.20E-03	2.63E-03	3.31E-04	9.20E-03	2.63E-03	3.31E-04
Silicon	1.58E-01	4.52E-02	5.70E-03	1.89E-01	5.41E-02	6.81E-03
Silver	9.52E-05	2.72E-05	3.43E-06	1.03E-04	2.96E-05	3.72E-06
Sodium	6.49E+01	1.85E+01	2.34E+00	5.56E+02	1.59E+02	2.00E+01
Strontium	3.66E-05	1.05E-05	1.32E-06	5.66E-05	1.62E-05	2.04E-06
Thallium	9.25E-03	2.64E-03	3.33E-04	9.25E-03	2.64E-03	3.33E-04
Tin	8.09E-03	2.31E-03	2.91E-04	8.79E-03	2.51E-03	3.16E-04
Titanium	6.10E-05	1.74E-05	2.20E-06	1.07E-04	3.07E-05	3.87E-06
Vanadium	2.34E-03	6.68E-04	8.42E-05	2.62E-03	7.49E-04	9.44E-05
Yttrium	NA	NA	NA	2.14E-05	6.11E-06	7.70E-07
Zinc	1.63E-02	4.65E-03	5.86E-04	3.34E-02	9.54E-03	1.20E-03
Organics						
1,1-Dichloroethene	6.53E-07	1.87E-07	2.35E-08			
1,2-Dichloroethene	5.99E-08	1.71E-08	2.16E-09			
1,2-Dichloropropane	1.60E-06	4.58E-07	5.77E-08			
1,3-Dimethylbenzene	2.09E-07	5.96E-08	7.51E-09			
Acetone	5.61E-06	1.60E-06	2.02E-07			
Ammonia	1.68E-01	4.79E-02	6.03E-03			
Benzene	3.82E-07	1.09E-07	1.37E-08			
Bromomethane	2.60E-08	7.43E-09	9.36E-10			
Carbon Tetrachloride	4.34E-07	1.24E-07	1.56E-08			
Chlorobenzene	1.15E-07	3.29E-08	4.15E-09			
Chloroform	7.50E-07	2.14E-07	2.70E-08			
Dicyclopentadiene	1.60E-07	4.57E-08	5.76E-09			
Ethylbenzene	2.38E-07	6.79E-08	8.55E-09			
Methanol	1.38E-02	3.94E-03	4.96E-04			
Methylene Chloride	7.29E-06	2.08E-06	2.62E-07			
Tetrachlorethene	3.93E-07	1.12E-07	1.42E-08			
Toluene	6.83E-08	1.95E-08	2.46E-09			
Trichloroethene	1.28E-06	3.66E-07	4.62E-08			
Xylene	7.59E-07	2.17E-07	2.73E-08			
4-Chlorophenylmethylsulfone	3.94E-04	1.13E-04	1.42E-05			
4-Chlorophenylmethylsulfoxide	4.86E-05	1.39E-05	1.75E-06			

TABLE 1. **EMISSION RATES FOR ROCKY MOUNTAIN ARSENAL BASIN F WASTE SUBMERGED QUENCH INCINERATOR (continued)**

Category/ Pollutant	Base Case (a) (ton/yr)	(lb/hr)	(g/sec) (c)	Sensitivity Case (b) (ton/yr)	(lb/hr)	(g/sec) (c)
Organic						
4-Nitrophenol	3.02E-05	8.62E-06	1.09E-06			
Aldrin	3.63E-06	1.04E-06	1.31E-07			
Atrazine	7.95E-07	2.27E-07	2.86E-08			
Hydrogen Cyanide	3.38E-06	9.66E-07	1.22E-07			
Dieldrin	7.44E-07	2.13E-07	2.68E-08			
Diisopropyl Methylphosphonate	1.25E-04	3.58E-05	4.50E-06			
Dimethyl Methylphosphonate	3.09E-03	8.83E-04	1.11E-04			
Dimethyldisulfide	3.61E-04	1.03E-04	1.30E-05			
Dithiane	1.26E-07	3.61E-08	4.55E-09			
Endrin	7.23E-07	2.07E-07	2.60E-08			
Hexachlorocyclopentadiene	6.69E-06	1.91E-06	2.41E-07			
Isodrin	1.88E-06	5.38E-07	6.78E-08			
Malathion	2.93E-06	8.36E-07	1.05E-07			
Parathion	3.98E-07	1.14E-07	1.43E-08			
Supona	1.23E-06	3.51E-07	4.42E-08			
Urea	5.17E-01	1.48E-01	1.86E-02			
Vapona	3.22E-06	9.19E-07	1.16E-07			
p,p-DDE	3.94E-07	1.13E-07	1.42E-08			
p,p-DDT	1.23E-06	3.51E-07	4.42E-08			
PICs with Specific Precursors						
Vinyl Chloride	7.07E-04	2.02E-04	2.55E-05			
Methyl Chloride	7.03E-04	2.01E-04	2.53E-05			
Styrene	7.05E-04	2.01E-04	2.54E-05			
Phenol	3.81E-03	1.09E-03	1.37E-04			
Benzaldehyde	7.32E-04	2.09E-04	2.64E-05			
Benzoic Acid	3.54E-04	1.01E-04	1.27E-05			
Acetonitrile	3.38E-06	9.66E-07	1.22E-07			
Acrylonitrile	3.38E-07	9.66E-08	1.22E-08			
Cyanogen	3.38E-08	9.66E-09	1.22E-09			
Hexachlorobenzene	2.40E-06	6.87E-07	8.66E-08			
Pentachlorobenzene	1.07E-06	3.07E-07	3.87E-08			
Tetrachlorobenzene	4.54E-07	1.30E-07	1.63E-08			
Trichlorobenzene	2.41E-07	6.89E-08	8.68E-09			
Dichlorobenzene	1.29E-07	3.68E-08	4.64E-09			
Biphenyl	3.56E-04	1.02E-04	1.28E-05			
4-Chlorobiphenyl	2.38E-03	6.79E-04	8.55E-05			
4,4-Chlorobiphenyl	4.47E-05	1.28E-05	1.61E-06			
Benzonitrile	3.38E-07	9.66E-08	1.22E-08			
Pyridine	3.38E-08	9.66E-09	1.22E-09			
Carbazole	6.76E-08	1.93E-08	2.43E-09			
Quinoline	1.69E-07	4.83E-08	6.09E-09			
PICs without Specific Precursors						
Benzofuran	1.40E-03	4.01E-04	5.06E-05			
Dibenzofuran	7.02E-05	2.01E-05	2.53E-06			
Acenaphthalene	3.51E-04	1.00E-04	1.26E-05			
Acenaphthene	3.51E-04	1.00E-04	1.26E-05			
Fluoranthene	2.11E-04	6.02E-05	7.58E-06			
Phenanthrene	1.40E-04	4.01E-05	5.06E-06			
Pyrene	7.02E-05	2.01E-05	2.53E-06			
Fluorene	7.02E-05	2.01E-05	2.53E-06			
Benzo(a)pyrene	7.02E-05	2.01E-05	2.53E-06			
Dibenzo(a)anthracene	7.02E-05	2.01E-05	2.53E-06			
Chrysene	7.02E-05	2.01E-05	2.53E-06			

TABLE 1. EMISSION RATES FOR ROCKY MOUNTAIN ARSENAL BASIN F WASTE SUBMERGED QUENCH INCINERATOR (continued)

Category/ Pollutant	Base Case (a) (ton/yr)	Base Case (a) (lb/hr)	Base Case (a) (g/sec) (c)	Sensitivity Case (b) (ton/yr)	Sensitivity Case (b) (lb/hr)	Sensitivity Case (b) (g/sec) (c)
Acid Gases & Other Compounds						
Particulate Matter	14.00 (d)	4.00	0.50	14.00	4.00	0.50
Carbon Monoxide	4.71	1.35	0.17	7.29 (f)	2.08	0.26
Hydrogen Chloride	4.73 (e)	1.35	0.17	14.00 (g)	4.00	0.50
Hydrogen Fluoride	5.23	1.494	0.188	15.35	4.385	0.552
Nitric Acid	3.85	1.10	0.14	3.85	1.10	0.14
Nitrogen Dioxide	32.13	9.18	1.16	143.22 (g)	40.92	5.16
Phosphate	1.77	0.51	0.06	3.51	1.00	0.13
Sulfuric Acid	10.40	2.97	0.37	17.34	4.96	0.62
Sulfur Dioxide	24.43 (e)	6.98	0.88	101.50 (g)	29.00	3.65

(a) These estimates are based upon the acceptable results during the test burn for dioxins/furans and the maximum of the acceptable test results or the maximum of the averages waste stream data for inorganics (including metals, acid gases and other compounds). The volatile and semi-volatile organic emissions are based upon Dellinger's analysis of the maximum of the averages wastestream data.

(b) For metals: based upon the maximum value of the test results from the test burn, the maximum of the maximum values from the wastestream data, and the EPA Guidance Tier II limits for complex terrain.
For dioxins/furans: based upon the 95% confidence interval from WESTON's hazardous waste incinerator emissions database.
For acid gases & other compounds: based upon the maximum value of the test results from the test burn and the maximum of the maximum values from the wastestream data.

(c) Assuming 7000 operating hours per year.

(d) Based upon Colorado's emission limitation of 0.08 gr/dscf @ 12% CO_2.

(e) Based upon the February 1989 test burn, which tested for the specific compound.

(f) Based upon Federal emission limitation of 100 ppm.

(g) Based upon vendor performance guarentees.

TABLE 2.

EXPECTED ACID & OTHER COMPOUNDS EMISSIONS BASED ON TEST BURN EMISSIONS & WASTE STREAM DATA

Original Pollutant	Based on Waste Stream Data: Waste Feedrate (1) (lb/ton)	Converted Pollutant	Uncontrolled Emissions (2) (lb/ton)	Removal Efficiency (%)	Controlled Emissions (3) (lb/ton)	Based upon Acceptable Test Burn Data: Controlled Emissions (4) (lb/ton)	Maximum Emissions Between the Two Scenarios (5) (lb/ton)	(lb/hr)
Particulate Matter (PM)	NA	PM	NA	NA	NA	NA	NA	4.00 (6)
Carbon Monoxide (CO)	NA	CO	NA	NA	NA	0.261	0.261	1.35
Chloride (Cl)	215.5	HCl	221.7	95	11.1	NA	NA	1.35 (8)
Fluoride (F)	0.18	HF	0.2	95	0.009	NA	0.009	0.05
Nitrate (NO3)	2.1	HNO3	2.1	90	0.213	NA	0.213	1.10
Nitrogen (N)	110.5	NO2	362.9	0	362.9	1.778	1.778	9.18
Phosphorus (P)	31.7	PO4	31.7	99.4	0.190	0.098	0.190	0.98
Sulfate (SO4)	56.4	H2SO4	57.6	99	0.6	NA	0.58	2.97
Sulfur (S)	NA	SO2	NA	90	NA	NA	NA	6.98 (8)

MAXIMUM ACID & OTHER COMPOUNDS EMISSIONS BASED ON TEST BURN EMISSIONS & WASTE STREAM DATA

Original Pollutant	Based on Waste Stream Data: Waste Feedrate (1) (lb/ton)	Converted Pollutant	Uncontrolled Emissions (2) (lb/ton)	Removal Efficiency (%)	Controlled Emissions (3) (lb/ton)	Based upon Test Burn Data: Controlled Emissions (4) (lb/ton)	Maximum Emissions Between the Two Scenarios (5) (lb/ton)	(lb/hr)
Particulate Matter (PM)	NA	PM	NA	NA	NA	NA	NA	4.00 (6)
Carbon Monoxide (CO)	NA	CO	NA	NA	NA	0.403 (7)	0.403	2.08
Chloride (Cl)	318.0	HCl	327.1	95	16.4	NA	NA	4.00 (9)
Fluoride (F)	0.34	HF	0.4	95	0.018	NA	0.018	0.09
Nitrate (NO3)	2.1	HNO3	2.1	90	0.213	NA	0.213	1.10
Nitrogen (N)	168.4	NO2	553.0	0	553.0	NA	NA	40.92 (9)
Phosphorus (P)	138.7	PO4	138.7	99.4	0.832	0.038	0.832	4.30
Sulfate (SO4)	94.0	H2SO4	96.0	99	1.0	NA	0.96	4.96
Sulfur (S)	NA	SO2	NA	90	NA	NA	NA	29.00 (9)

(1) Based upon the maximum of the maximums emission concentration from historical test data (tons/yr) and multiplying by 2000 lbs/ton / ((10,325 lbs of waste/hr / 2000 lbs/ton) x 7,000 operating hrs/yr).
(2) Based upon the waste feed rate x the molecular weight of the converted pollutant the molecular weight of the orginal pollutant.
(3) Controlled Emissions = Uncontrolled Emissions x (1- % Removal Efficiency)
(4) Based upon the average emission during the test burn by T-Thermal in Aug. 1990.
(5) The maximum values were used for all pollutants, except NO2, for which the test burn data was used.
(6) Particulate is based upon Colorodo regulations of 0.08 gr/dscf @ 12% CO2.
(7) Carbon monoxide is based upon Federal regulations of 100 ppm.
(8) Based upon February 1989 test burn which tested for the specific compounds.
(9) Based upon [illegible] performance [illegible]

TABLE 3

Chemicals of Concern Evaluated[1] in Tier 1 Surface Water Screening Analysis For Rocky Mountain Arsenal

03-Dec-90
02:46:14 PM

POLLUTANTS	EMISSION RATE (g/sec)	TOTAL DEPOSITION RATE (g/m2*yr)	TOTAL BASIN DEPOSITION (g/yr)	WATER CONCENTRATION (mg/l)	AWQCs FISH INGESTION (mg/l)
ORGANICS					
Fluoranthene	1.91E-09	1.72E-12	2.23E-07	3.23E-13	5.40E-02
Pentachlorobenzene	9.73E-12	8.76E-15	1.13E-09	1.64E-15	8.50E-02
Tetrachlorobenzene	4.11E-12	3.70E-15	4.79E-10	6.93E-16	4.80E-02
INORGANICS					
Antimony	3.90E-03	3.51E-06	4.55E-01	6.58E-07	4.50E+01
Chromium (III)	1.20E-05	1.08E-08	1.40E-03	2.02E-09	3.43E+03
Manganese	2.50E-04	2.25E-07	2.91E-02	4.22E-08	1.00E-01
Mercury	3.90E-03	3.51E-06	4.55E-01	6.58E-07	1.46E-04
Nickel	1.07E-03	9.63E-07	1.25E-01	1.81E-07	1.00E-01
Thallium	3.90E-03	3.51E-06	4.55E-01	6.58E-07	4.80E-02

9.00E-04 Total deposition factor (g/m2*yr)/(g/sec)
1.30E+05 Total basin area (m2)
5.00E-01 Hydraulic residence time (yr)
3.45E+05 Lake volume (m3)
1.00E-03 Conversion factor (m3/l)
1.00E+03 Conversion factor (mg/g)

TDR = ER*TDF
TBD = TDR*TBA
Cwater = TBD*HRT*CF*CF/VOL

[1] All chemicals evaluated in this analysis will be excluded from the surface water pathway in the risk assessment.

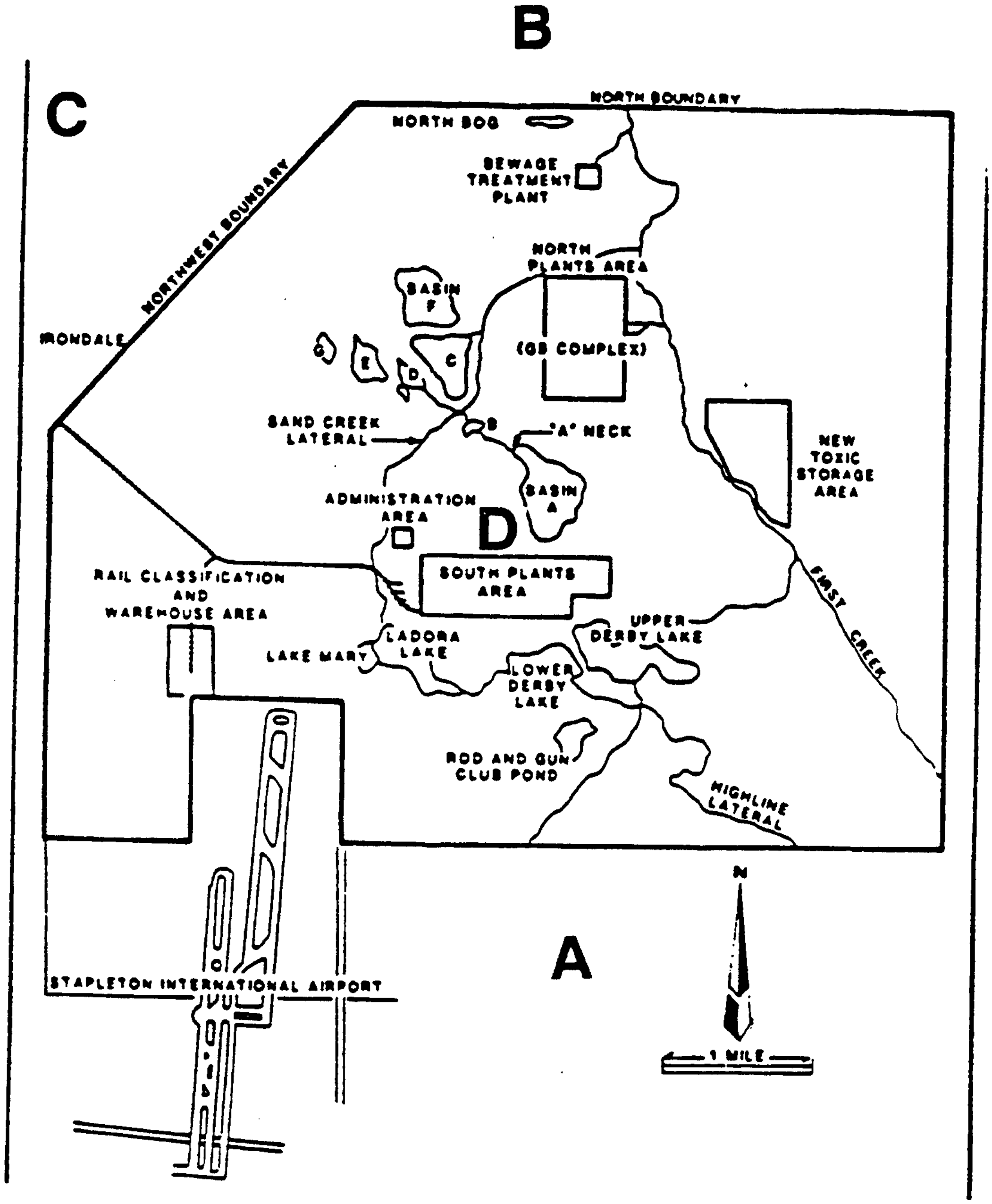

FIGURE 1. Locations of Reasonable, Maximally-Exposed Individuals Based Upon Ambient Air and Deposition Modeling Data.

(A) Area of maximum total deposition (residential); (B) Area of maximum dry deposition and maximum ambient groundlevel air concentration (residential); (C) Area of maximum total deposition for local cattle farm; (D) A maintenance worker on-site exposed to area weighted total deposition and ambient groundlevel air concentrations.

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TABLE 4A

Rocky Mountain Arsenal (RMA)
Slope Factors for
Carcinogenic Health Effects
(mg/kg/day^-1)

Pollutant	EPA Carcinogenicity Classification	IARC Carcinogenicity Classification	Inhalation Route Slope Factor	Reference or Basis of Inhalation Slope Factor	Oral Route Slope Factor	Reference or Basis of Oral Slope Factor	Dermal Route Slope Factor
Organics							
Acrylonitrile	B1	2A	2.40E-01	IRIS, 1990	5.40E-01	IRIS, 1990	NC
Aldrin	B2	3	1.70E+01	IRIS, 1990	1.70E+01	IRIS, 1990	3.40E+01
Benzene	A	1	2.90E-02	IRIS, 1990	2.90E-02	IRIS, 1990	NC
Carbazole	B2	3	2.00E-02	OSF	2.00E-02	EBASCO, 1990	4.00E-02
Carbon Tetrachloride	B2	2B	1.30E-01	IRIS, 1990	1.30E-01	IRIS, 1990	NC
Chloroform	B2	2B	8.10E-02	IRIS, 1990	6.10E-03	IRIS, 1990	NC
DDE	B2		3.40E-01	OSF	3.40E-01	IRIS, 1990	6.80E-01
DDT	B2	2B	3.40E-01	IRIS, 1990	3.40E-01	IRIS, 1990	6.80E-01
1,4-Dichlorobenzene	B2	2B	2.40E-02	ORD EPA, 1990	2.40E-02	EPA, 1990	NC
1,1-Dichloroethene	C		1.20E+00	IRIS, 1990	6.00E-01	IRIS, 1990	NC
1,2-Dichloropropane	B2	3	6.80E-02	ORD EPA, 1990	6.80E-02	EPA, 1990	NC
Dieldrin	B2	3	1.60E+01	IRIS, 1990	1.60E+01	IRIS, 1990	3.20E+01
Dioxins/Furans (as 2,3,7,8 TCDD)	B2	2B	1.13E+05	EPA, 1990	1.50E+05	EPA, 1990	3.00E+05
Hexachlorobenzene	B2	2B	1.60E+00	EPA, 1990	1.60E+00	EPA, 1990	3.20E+00
Methyl Chloride	C	3	6.30E-03	EPA, 1990	1.30E-02	EPA, 1990	NC
Methylene Chloride	B2		1.40E-02	EPA, 1990	7.50E-03	EPA, 1990	NC
PAHs	—	—	—	—	—	—	—
Benzo[a]pyrene	B2	2A	6.10E+00	EPA, 1986	1.15E+01	EPA, 1986	2.30E+01
Chrysene	B2	3	6.10E+00	EPA, 1986	1.15E+01	EPA, 1986	2.30E+01
Dibenzo[a]anthracene		2A,3	6.10E+00	EPA, 1986	1.15E+01	EPA, 1986	2.30E+01
Parathion	C						
Quinoline	C		1.20E+01	ORD	1.20E+01	EPA, 1990	2.40E+01
Styrene	B2	2B	2.00E-03	EPA, 1990	3.00E-02	EPA, 1990	NC
Tetrachloroethene	B2				5.10E-02	EPA, 1990	NC
Trichloroethene	B2	3	1.10E-02	EPA, 1990	1.10E-02	EPA, 1990	NC
Vapona	B2	3	2.90E-01	ORD	2.90E-01	IRIS, 1990	5.80E-01
Vinyl Chloride	A	1	2.95E-01	EPA, 1990	2.30E+00	EPA, 1990	NC

TABLE 4A (continued)

Rocky Mountain Arsenal (RMA)

Slope Factors for

Carcinogenic Health Effects

(mg/kg/day^-1)

Pollutant	EPA Carcinogenicity Classification	IARC Carcinogenicity Classification	Inhalation Route Slope Factor	Reference or Basis of Inhalation Slope Factor	Oral Route Slope Factor	Reference or Basis of Oral Slope Factor	Dermal Route Slope Factor
Inorganics							
Arsenic	A	1	1.50E+01	IRIS, 1990	1.75E+00	EPA, 1990	3.50E+01
Beryllium	B2		8.40E+00	IRIS, 1990	4.30E+00	IRIS, 1990	8.60E+01
Cadmium	B1	2A	6.10E+00	IRIS, 1990	NC	—	NC
Chromium (VI)	A	1	4.10E+01	IRIS, 1990	NC	—	NC
Nickel (as soluble salts)	A	1	2.00E-02	IRIS, 1990	NC	—	NC

NC = Not of Concern

NE = Not Evaluated

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TABLE 4B

Rocky Mountain Arsenal (RMA)
Reference Doses (RfDs) for
Noncarcinogenic Health Effects
(mg/kg/day)

Pollutant	Inhalation Route RfD	Reference or Basis of Inhalation RfD	Oral Route RfD	Reference or Basis of Oral RfD	Dermal Route RfD
Organics					
Acetone	1.82E+00	ACGIH-TWA	1.00E-01	EPA, 1990	NC
Acetonitrile	1.00E-02	EPA,1990	6.00E-02	EPA, 1990	3.00E-02
Acrylonitrile	4.39E-03	ACGIH-TWA	2.70E-04	Derived	NC
Aldrin	2.55E-04	ACGIH-TWA	3.00E-05	IRIS, 1990	1.50E-05
Atrazine	5.10E-03	ACGIH-TWA	5.00E-03	IRIS, 1990	2.50E-03
Benzaldehyde	1.00E-01	Oral RfD	1.00E-01	IRIS, 1990	5.00E-02
Benzene	3.26E-02	ACGIH-TWA	1.00E-03	Derived	NC
Benzofuran	5.00E-03	Oral RfD	5.00E-03	Derived	2.50E-03
Benzoic Acid	4.00E+00	Oral RfD	4.00E+00	IRIS, 1990	2.00E+00
Benzonitrile	8.00E-03	Oral RfD	8.00E-03	Derived	4.00E-03
Biphenyl	1.33E-03	ACGIH-TWA	5.00E-02	EPA, 1990	NC
Bromomethane	1.71E-02	EPA, 1990	1.40E-03	IRIS, 1990	NC
Carbazole	5.00E-03	Oral RfD	5.00E-03	Derived	2.50E-03
Carbon Tetrachloride	3.16E-02	ACGIH-TWA	7.00E-04	IRIS, 1990	NC
Chlorobenzene	5.00E-03	EPA, 1990	2.00E-02	IRIS, 1990	NC
4-Chlorobiphenyl	2.45E-02	Oral RfD	2.45E-02	Derived	1.22E-02
4,4'-Chlorobiphenyl	2.33E-02	Oral RfD	2.33E-02	Derived	1.16E-02
Chloroform	5.00E-02	ACGIH-TWA	1.00E-02	IRIS, 1990	NC
4-Chlorophenylmethylsulfone	1.98E-02	Oral RfD	1.98E-02	EBASCO, 1990	9.90E-03
4-Chlorophenylmethylsulfoxide	1.98E-02	Oral RfD	1.98E-02	EBASCO, 1990	9.90E-03
DDE	5.00E-04	Oral RfD	5.00E-04	IRIS, 1990	2.50E-04
DDT	1.02E-03	ACGIH-TWA	5.00E-04	IRIS, 1990	2.50E-04
Dibenzofuran					
Dichlorobenzene	4.00E-02	EPA, 1990	9.00E-02	EPA, 1990	NC
1,4-Dichlorobenzene					
1,1-Dichloroethene	2.04E-02	ACGIH-TWA	9.00E-02	EPA, 1990	NC
1,2-Dichloroethene(total)	8.10E-01	ACGIH-TWA	9.00E-03	IRIS, 1990	NC
1,2-Dichloropropane	3.54E-01	ACGIH-TWA	8.60E-03	Derived	NC

TABLE 4B (continued)

Rocky Mountain Arsenal (RMA)

Reference Doses (RfDs) for

Noncarcinogenic Health Effects

(mg/kg/day)

Pollutant	Inhalation Route RfD	Reference or Basis of Inhalation RfD	Oral Route RfD	Reference or Basis of Oral RfD	Dermal Route RfD
Dicyclopentadiene	6.00E-05	EPA, 1991	3.00E-02	EPA, 1991	1.50E-02
Dieldrin	2.55E-04	ACGIH-TWA	5.00E-05	IRIS, 1990	2.50E-05
Diisopropyl Methylphosphonate	8.00E-02	Oral RfD	8.00E-02	IRIS, 1990	4.00E-02
1,3-Dimethylbenzene	2.00E-01	EPA, 1990	5.00E-02	Derived	2.50E-02
Dimethyldisulfide	8.10E-03	Oral RfD	8.10E-03	EBASCO, 1990	NC
Dimethyl Methylphosphonate	1.80E-02	Oral RfD	1.80E-02	EBASCO, 1990	9.00E-03
Dioxins/Furans (as 2,3,7,8 TCDD)	1.00E-09	Oral RfD	1.00E-09	ATSDR, 1989	5.00E-10
Dithiane	1.00E-02	Oral RfD	1.00E-02	EBASCO, 1990	5.00E-03
Endrin	1.02E-04	ACGIH-TWA	3.00E-04	IRIS, 1990	1.50E-04
Ethylbenzene	4.43E-01	ACGIH-TWA	1.00E-01	IRIS, 1990	NC
Hexachlorobenzene	8.00E-04	Oral RfD	8.00E-04	IRIS, 1990	4.00E-04
Hexachlorocyclopentadiene (HCCPD)	2.00E-05	EPA, 1990	7.00E-03	IRIS, 1990	3.50E-03
Isodrin	7.00E-05	Oral RfD	7.00E-05	EBASCO, 1990	3.50E-05
Malathion	1.02E-02	ACGIH-TWA	2.00E-02	IRIS, 1990	1.00E-02
Methanol	2.67E-01	ACGIH-TWA	5.00E-01	IRIS, 1990	2.50E-01
Methyl Chloride	1.05E-01	ACGIH-TWA	1.80E-02	Derived	NC
Methylene Chloride	8.57E-01	EPA, 1990	6.00E-02	EPA, 1990	NC
4-Nitrophenol	2.50E-03	Oral RfD	2.50E-03	Derived	1.25E-03
PAHs	—	—	—	—	—
Acenaphthalene	6.00E-02	Oral RfD	6.00E-02	IRIS, 1990	3.00E-02
Acenaphthene	6.00E-02	Oral RfD	6.00E-02	EPA, 1990	3.00E-02
Benzo[a]pyrene	3.00E-02	Oral RfD	3.00E-02	IRIS, 1990	1.50E-02
Chrysene	3.00E-02	Oral RfD	3.00E-02	IRIS, 1990	1.50E-02
Dibenzo[a,h]anthracene	3.00E-02	Oral RfD	3.00E-02	IRIS, 1990	1.50E-02
Fluoranthene	4.00E-02	Oral RfD	4.00E-02	EPA, 1990	2.00E-02
Fluorene	4.00E-02	Oral RfD	4.00E-02	IRIS, 1990	2.00E-02
Phenanthrene	3.00E-02	Oral RfD	3.00E-02	EPA, 1990	1.50E-02
Pyrene	3.00E-02	Oral RfD	3.00E-02	IRIS, 1990	1.50E-02
Parathion	5.10E-05	REL	6.00E-03	EPA, 1990	3.00E-03
Pentachlorobenzene	8.00E-04	Oral RfD	8.00E-04	IRIS, 1990	4.00E-04

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TABLE 4B (continued)

Rocky Mountain Arsenal (RMA)
Reference Doses (RfDs) for
Noncarcinogenic Health Effects
(mg/kg/day)

Pollutant	Inhalation Route RfD	Reference or Basis of Inhalation RfD	Oral Route RfD	Reference or Basis of Oral RfD	Dermal Route RfD
Phenol	1.94E-02	ACGIH-TWA	6.00E-01	IRIS, 1990	3.00E-01
Pyridine	1.63E-02	ACGIH-TWA	1.00E-03	IRIS, 1990	NC
Quinoline	2.00E-01	Oral RfD	2.00E-01	IRIS, 1990	1.00E-01
Styrene	2.17E-01	ACGIH-TWA	2.00E-01	IRIS, 1990	NC
Supona	1.50E-04	Oral RfD	1.50E-04	EBASCO, 1990	7.50E-05
Tetrachlorobenzene	3.00E-04	Oral RfD	3.00E-04	IRIS, 1990	1.50E-04
Tetrachloroethene	3.46E-01	ACGIH-TWA	1.00E-02	IRIS, 1990	NC
Toluene	5.71E-01	EPA, 1990	2.00E-01	IRIS, 1990	NC
Trichlorobenzene	3.00E-03	EPA, 1990	2.00E-02	EPA, 1990	1.00E-02
Trichloroethene	2.74E-01	ACGIH-TWA	7.35E-03	EPA, 1987	NC
Urea	8.47E-02	Oral RfD	8.47E-02	Derived	4.28E-02
Vapona	8.00E-04	Oral RfD	8.00E-04	IRIS, 1990	4.00E-04
Vinyl Chloride	1.33E-02	ACGIH-TWA	1.30E-03	Derived	NC
Xylenes (total)	8.57E-02	EPA, 1990	2.00E+00	EPA, 1990	NC
Inorganics					
Aluminum	2.04E-03	ACGIH-TWA	NE	—	NC
Ammonia	1.73E-02	ACGIH-TWA	NE	—	NC
Antimony	5.10E-04	ACGIH-TWA	4.00E-04	IRIS, 1990	2.00E-05
Arsenic	2.04E-04	ACGIH-TWA	1.00E-03	EPA, 1990	5.00E-05
Barium	1.00E-04	EPA, 1990	NE	—	3.50E-03
Beryllium	2.04E-06	ACGIH-TWA	5.00E-03	IRIS, 1990	2.50E-04
Boron	4.11E-03	ACGIH-TWA	NE	—	NC
Cadmium	5.10E-05	ACGIH-TWA	1.00E-03	IRIS, 1990	5.00E-05
Calcium	1.46E-03	ACGIH-TWA	NC	—	NC
Chromium (III)	5.10E-04	ACGIH-TWA	NE	—	NC
Chromium (VI)	5.10E-05	ACGIH-TWA	5.00E-03	IRIS, 1990	NC
Cobalt	5.10E-05	ACGIH-TWA	2.30E-03	Derived	NC

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TABLE 4B (continued)

Rocky Mountain Arsenal (RMA)
Reference Doses (RfDs) for
Noncarcinogenic Health Effects
(mg/kg/day)

Pollutant	Inhalation Route RfD	Reference or Basis of Inhalation RfD	Oral Route RfD	Reference or Basis of Oral RfD	Dermal Route RfD
Copper	1.00E-02	EBASCO, 1990	3.80E-02	EBASCO, 1990	1.90E-03
Cyanogen	2.14E-02	ACGIH-TWA	NE	—	NC
Hydrogen Cyanide	5.10E-03	ACGIH-TWA	NE	—	NC
Iron	1.02E-03	ACGIH-TWA	NE	—	NC
Lithium	1.00E-04	Derived	NE	—	NC
Magnesium	6.15E-03	ACGIH-TWA	NE	—	NC
Manganese	3.00E-04	EPA, 1990	NE	—	NC
Mercury	8.57E-05	EPA, 1990	3.00E-04	EPA, 1990	1.50E-05
Molybdenum	5.10E-03	ACGIH-TWA	NE	—	NC
Nickel	1.02E-04	ACGIH-TWA	NE	—	NC
Phosphate			NC	—	NC
Potassium			NC	—	NC
Selenium	2.04E-04	ACGIH-TWA	3.00E-03	EPA, 1990	NC
Silicon	5.10E-05	ACGIH-TWA	NC	—	NC
Silver	1.02E-05	ACGIH-TWA	3.00E-03	IRIS, 1990	NC
Sodium			NC	—	NC
Strontium			NE	—	NC
Thallium	1.02E-04	ACGIH-TWA	7.00E-05	EPA, 1990	NC
Tin	2.04E-03	ACGIH-TWA	NE	—	NC
Titanium	6.11E-03	ACGIH-TWA	NE	—	NC
Vanadium	5.10E-05	ACGIH-TWA	7.00E-03	EPA, 1990	NC
Yttrium	1.02E-03	ACGIH-TWA	NE	—	NC
Zinc	8.19E-03	ACGIH-TWA	2.00E-01	EPA, 1990	NC

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TABLE 4B (continued)

Rocky Mountain Arsenal (RMA)

Reference Doses (RfDs) for

Noncarcinogenic Health Effects

(mg/kg/day)

Pollutant	Inhalation Route RfD	Reference or Basis of Inhalation RfD	Oral Route RfD	Reference or Basis of Oral RfD	Dermal Route RfD
Other Acid Gases/ Criteria Pollutants					
Carbon Monoxide	5.81E-02	ACGIH-TWA			
Hydrogen Chloride	7.65E-03	ACGIH-TWA			
Hydrogen Fluorides	2.65E-03	ACGIH-TWA			
Nitric Acid	5.30E-03	ACGIH-TWA			
Nitrogen Dioxide	2.86E-02	NAAQS			
Particulate Matter	4.29E-02	NAAQS			
Sulfur Dioxide	2.29E-02	NAAQS			
Sulfuric Acid Mist	1.02E-03	ACGIH-TWA			

NC = Not of Concern

NE = Not Evaluated

NA = Not Applicable

APPENDIX 7A

DERIVATION OF SURFACE WATER POLLUTANT CONCENTRATIONS FOR ENGINEERS LAKE

APPENDIX 7A

DERIVATION OF SURFACE WATER POLLUTANT CONCENTRATIONS FOR ENGINEERS LAKE

7A.1 INTRODUCTION

This appendix presents a detailed discussion of the methods used to determine the surface water contaminant concentrations for Engineers Lake. The Tier 1 analysis describes the technique used initially to screen contaminants from further evaluation in the surface water pathways (EPA, 1986). The Tier 2 analysis explains the derivation of final contaminant concentrations used in estimating the exposure doses for the fish ingestion pathway in the risk assessment.

7A.2 TIER 1 ANALYSIS

The focus of the Tier 1 screening was to eliminate minor contaminants from the fish ingestion pathway, which is the only surface water-related pathway evaluated in the risk assessment. Water concentrations of certain contaminants were predicted using a Tier 1 methodology and compared with the appropriate health-based criteria. Contaminants predicted to have water concentrations exceeding 10% of their respective health-based criteria were selected for further evaluation in the risk assessment. Those contaminants with concentrations less than 10% of their respective health-based criteria were not subsequently evaluated.

With the objective of developing a conservative carcinogenic risk estimate, all oral carcinogens are arbitrarily evaluated through all relevant exposure pathways in the final risk assessment, and were not screened in the Tier 1 analysis. Volatile organic compounds were not considered in this analysis since they are neither expected to accumulate in surface water nor bioaccumulate in fish.

Nonvolatile, noncarcinogenic compounds that had ambient water quality criteria for the protection of human health through fish ingestion or water and fish ingestion were screened in the Tier 1 analysis. These factors resulted in the evaluation of the contaminants listed below.

Organics
Diethylphthalate
Dimethylphthalate
Di-n-butylphthalate

Inorganics
Antimony
Barium
Cadmium
Chromium (III)
Chromium (VI)
Iron
Lead
Manganese
Mercury
Nickel
Silver

The lower of the 95% upper confidence limit (UCL) on the arithmetic mean or the maximum emission rate was used in the Tier I screening to be consistent with the remaining calculations in the risk assessment. It was conservatively assumed that all contaminants deposited in the watershed of Engineers Lake in a 1-year period would enter the lake as runoff. The decay and degradation of contaminants in surface water, soil, or air were not considered in this analysis, further maximizing the predicted lake water concentrations. The equations employed in the Tier 1 screening are presented in the following text.

The total annual basin deposition rate was calculated using the following equation:

$$TBD = ER * DR * BA$$

Where:

TBD	=	Total basin deposition (g/yr)
ER	=	Emission rates (g/sec)
DR	=	Total (wet plus dry) deposition factor, 9.00E-04 $(g/m^2\ yr)/(g/sec)$
BA	=	Basin area, 1.30E+05 m^2

The water concentration in Engineers Lake was calculated using the following equation:

$$Cwater = TBD * HRT * CF1 * CF2/VOL$$

Where:

Cwater	=	Contaminant concentration in Engineers Lake (mg/L).
TBD	=	Total basin deposition (g/yr).
HRT	=	Hydraulic residence time (assumed 0.5 yr).
CF1	=	Conversion factor, 1.00E-03 m^3/L.
CF2	=	Conversion factor, 1.00E+03 mg/g.
VOL	=	Lake volume, 3.45E+05 m^3 (Nancy Koenig, personal communication, 1990).

The emission rates, water concentrations, and ambient water quality criteria used in the Tier 1 screening are presented in Table 7A-1. Table 7A-1 shows that none of the contaminants eligible for the Tier 1 screening exceeds 10% of their respective ambient water quality criteria for protection of human health through fish or water ingestion. As a result, these compounds are not evaluated in the fish ingestion pathway.

7A.3 TIER 2 ANALYSIS

A Tier 2 transport model was developed to predict surface water contaminant concentration from soil runoff and aerial deposition of pollutants in Engineers Lake for the fish ingestion pathway. The Tier 2 model employs more realistic assumptions and provides more realistic values than the Tier 1 model. Water concentrations were calculated for all pollutants except particulate matter, acid gases, volatile organic compounds, and contaminants

excluded as a result of the Tier 1 analysis. The technical approach and assumptions of the Tier 2 model are presented in the subsections that follow.

7A.3.1 Prediction of Surface-Water Concentrations of Pollutants

To estimate the potential exposure to the pollutants through fish consumption, surface water pollutant concentrations were predicted using the following steps:

- Calculation of the average deposition rate within the watershed.
- Estimation of soil loss to Engineers Lake within the watershed.
- Determination of pollutant concentrations in Engineers Lake.

This approach to determining surface-water concentrations is based on the estimation of pollutant deposition on Engineers Lake and watershed soils and the subsequent runoff of pollutants to the lake. The concentrations are based on an assumed facility life of 2 years.

7A.3.2 Calculation of the Average Deposition Rate (DR) Within the Watershed

The first step in estimating the chronic surface-water concentrations involves a determination of the deposition factor for the impacted area. The watershed of Engineers Lake is limited in size and surrounded by major roadways. Due to the small size of the watershed, deposition in the entire area was described by a single rate, which precluded having to average the deposition over a wider area. The total deposition factor for the watershed is 9.00E-04 $(g/m^2yr)/(g/sec)$.

7A.3.3 Estimation of Soil Loss to Engineer's Lake

Data that could be used to predict soil erosion within the Engineers Lake watershed were not available. As a result, soil loss was conservatively estimated at 1.5 tons/acre-yr or 336 g/m^2-yr.

7A.3.3.1 Contaminant Loss Rate

To estimate the soil contaminant concentrations being transported to the lake, it is first necessary to estimate the rate constants for contaminant loss from soils. The contaminant loss rate is based on contaminant loss through one potential loss mechanism - the surface runoff rate (K_1), which is based on the loss of soil particles as they are transported to the lake.

The surface water runoff rate (K_1) was calculated as follows:

$$K_1 = X_t / (B * d)$$

Where:

			Estimated Value
K_1	=	Surface runoff rate	= 0.00118 per year
X_t	=	Total sediment loss rate	= 336.24 g/m^2-yr
B	=	Bulk density	= 1,425,000 g/m^3 (Alan Price, personal communication, 1990)
d	=	Depth of incorporation	= 0.2 meter

The contaminant loss rates for soils in the Engineers Lake watershed are presented in Table 7A-2.

No allowances were made for infiltration losses. Although these losses can be significant, it is beyond the scope of this analysis to determine the extent of groundwater recharge in the basin. Therefore, it is conservatively assumed that no loss to groundwater occurs. This conservative assumption increases the soil concentrations and thus the surface water concentrations.

7A.3.3.2 Determination of Steady State Soil Concentrations

Based on the rate of deposition and the loss of contaminants in soil from surface runoff and degradation, the steady state soil concentrations for each contaminant evaluated that will accumulate during the operation of the facility were calculated as follows:

$$MN = (K_2/K_1) * (1-e^{-K_1 t}) * CF/(d * B)$$

Where:

- Mn = Maximum contaminant soil concentration (g/kg).
- K_2 = Annual deposition rate for contaminant (g/m^2-year).
- K_1 = Contaminant loss rate (per year).
- t = Life of the incinerator (2 yrs).
- d = Depth of incorporation (0.2 m).
- B = Bulk density (1.425E+06 g/m^3).
- CF = Conversion factor (1,000 g/kg).

The annual deposition rates (K_2) were calculated by multiplying the chemical-specific emission rates by the deposition factor of 9.00E-04 g/m^2-year per g/sec. The maximum contaminant soil concentrations, as well as the emission rates and annual deposition rates used in the calculations, are presented in Table 7A-3.

7A.3.4 Determination of Contaminant Concentration (C) in the Receiving Water

The receiving water contaminant concentration is a function of the suspended solids in the inflow and outflow, as well as the concentration of contaminants in the soil. No data were available for the suspended solids concentration of Engineers Lake. Therefore, it was assumed that the lake had a suspended solids outflow concentration of 100 mg/L.

The inflowing suspended solids concentration was based on the conservative assumption that 95% of inflowing suspended sediments settle out in Engineers Lake. The equations used to calculate the impoundment contaminant concentration are:

Si = So/(1-RE)
Ci = Si * Mn * CF

Where:

Si = Suspended solids concentration in inflow (mg/L)
So = Suspended solids concentration in outflow (100 mg/L) (assumed value)
RE = Suspended solids removal efficiency (assume 95%)
Ci = Inflow total concentration (ng/L)
Mn = Maximum soil concentration (g/kg)
CF = Conversion factor, 1,000 mg/g

7A.3.5 Aerial Deposition on Engineers Lake

Direct aerial deposition onto Engineers Lake represents an additional source of pollutants. The contribution by direct deposition was calculated by first determining the total deposition factor for the lake. This factor, 9.00E-04, is the same as that described previously for soil loss.

The concentration due to deposition was calculated by determining the mass of pollutants falling onto 1 square meter of lake surface. The pollutant mass was then mixed in the volume of water underlying the square meter of lake surface, which was based on an average depth of 6 meters (Nancy Koenig, Personal Communication, 1990). An assumed hydraulic residence time of 0.5 year was factored into the final equation to account for pollutant loss by outflowing water. The equation used to calculate the concentration from direct deposition is:

Md = SA * K2i * Tr

Where:

Md = Mass deposited directly into unit volume (grams)
SA = Unit surface area (1 m^2)
K2i = Area-weighted deposition (g/yr m^2)
Tr = Hydraulic residence time (0.5 year)

The contaminant concentration from sedimentation and aerial deposition were combined in the following equation to form an intermediate water concentration:

$$Ci2 = Ci + ((Md * NGG)/Vp)$$

Where:

Ci2	=	Intermediate unit volume concentration (ng/L)
Ci	=	Contaminant concentration due to erosion losses (ng/L)
Md	=	Mass due to aerial deposition (g)
Vp	=	Volume of water under 1 m^2 of lake surface (L), based on average depth of 6.0 meters (Nancy Koenig, personal communication, 1990)
NGG	=	Conversion factor for grams to nanograms (1E+09 ng/g)

The concentration of contaminants in Engineers Lake is a function of the intermediate concentration, Ci2, the suspended solids concentration in outflow and inflow, and partitioning of the contaminant between dissolved and solid phases. The equation, which is presented below, represents the total water column concentration and takes into account dissolved and particle bound contaminants.

$$Ct = Ci2 * (1+(So * Kp * KGMG))/(1+Si * Kp * KGMG))$$

Where:

Ct	=	Total water column concentration
Ci2	=	Intermediate unit volume concentration (ng/L)
So	=	Suspended solids concentration in outflow (mg/L)
Kp	=	Partition coefficient (L/kg)
KGMG	=	Conversion factor (1E-06 kg/mg)
Si	=	Suspended solids concentration in inflow (mg/L)

The water concentrations and partition coefficients used in the fish ingestion pathway are presented in Tables 7A-4 and 7A-5, respectively.

APPENDIX 7A

CITED REFERENCES

EPA (U.S. Environmental Protection Agency). 1986. *Methodology for the Assessment of Health Risks Associated with Multiple Pathway Exposure to Municipal Waste Combustion Emissions.* Environmental Criteria and Assessment Office, Cincinnati, OH.

Koenig, N. 1990. Personal Communication. Adams County Parks Department.

Price, A. 1990. Personal Communication. USDA Soil Conservation Service, Denver, Colorado.

Table 7A-1

Tier 1 Surface Water Pollutant Concentrations and Comparison To Standards

Pollutant	Emission Rate (g/sec)	Predicted Annual Surface Water Concentration (mg/L)	AWQC for Protection of Human Health* (mg/L)
Organics			
Diethylphthalate	2.59E-05	5.56E-09	1.80E+03
Dimethylphthalate	9.82E-06	2.11E-09	2.90E+03
Di-n-butylphthalate	2.93E-05	6.29E-09	1.54E+02
Inorganics			
Antimony	2.06E-05	4.42E-09	4.50E+01
Barium	1.48E-04	3.18E-08	1.00E+00
Cadmium	3.79E-06	8.14E-10	1.00E-02
Chromium (III)	7.11E-06	1.53E-09	3.43E+03
Chromium (VI)	1.56E-06	3.35E-10	5.00E-02
Iron	1.69E-04	3.36E-08	3.00E-01
Lead	1.10E-04	2.36E-08	5.00E-02
Manganese	3.35E-05	7.19E-09	1.00E-01
Mercury	2.65E-04	5.69E-08	1.46E-04
Nickel	2.96E-05	6.36E-09	1.00E-01
Silver	7.36E-06	1.58E-09	5.00E-02

* EPA. 1986. Quality Criteria for Water. 1986. Office of Water Regulations and Standards. EPA 440/5-86-001.

Table 7A-2

Contaminant Loss Rates in the Engineers Lake Watershed

Pollutant	K_1 (/year)
ORGANICS	
Benzoic Acid	1.18E-03
Bis(2-ethylhexyl)phthalate	1.18E-03
Butylbenzylphthalate	1.18E-03
Dibromochloromethane	1.18E-03
Di-n-butylphthalate	1.18E-03
Dioxins/Furans (EPA TEFs)	1.18E-03
Heptachlor epoxide	1.18E-03
INORGANICS	
Aluminum	1.18E-03
Arsenic	1.18E-03
Boron	1.18E-03
Calcium	1.18E-03
Copper	1.18E-03
Molybdenum	1.18E-03
Tin	1.18E-03
Titanium	1.18E-03
Vanadium	1.18E-03
Zinc	1.18E-03

Table 7A-3

Maximum Contaminant Soil Concentrations, Emission Rates, and Annual Deposition Rates in the Engineers Lake Watershed

Pollutant	Soil Concentration (g/Kg)	Emission Rate g/sec	Annual Deposition (g/m2-year)
ORGANICS			
Benzoic Acid	3.24E-10	5.14E-05	4.63E-08
Bis(2-ethylhexyl)phthalate	1.23E-10	1.95E-05	1.76E-08
Butylbenzylphthalate	8.64E-11	1.37E-05	1.23E-08
Dibromochloromethane	5.04E-11	7.99E-06	7.19E-09
Di-n-butylphthalate	1.85E-10	2.93E-05	2.64E-08
Dioxins/Furans (EPA TEFs)	2.60E-17	4.12E-12	3.71E-15
Heptachlor epoxide	1.75E-12	2.78E-07	2.50E-10
INORGANICS			
Aluminum	2.36E-09	3.74E-04	3.37E-07
Arsenic	4.68E-10	7.42E-05	6.68E-08
Boron	4.35E-09	6.90E-04	6.21E-07
Calcium	2.33E-08	3.70E-03	3.33E-06
Copper	4.81E-08	7.63E-03	6.87E-06
Molybdenum	4.68E-10	7.42E-05	6.68E-08
Tin	3.14E-10	4.98E-05	4.48E-08
Titanium	4.68E-10	7.42E-05	6.68E-08
Vanadium	2.33E-10	3.70E-05	3.33E-08
Zinc	1.21E-08	1.91E-03	1.72E-06

Table 7A-4

Surface Water Concentrations for Contaminants of Concern in Fish Ingestion Exposure Pathways

Pollutant	Water Concentration for Fish Pathway (mg/L)
ORGANICS	
Benzoic Acid	3.90E-09
Bix(2-ethylhexyl)phthalate	8.43E-11
Butylbenzylphthalate	6.08E-11
Dibromochloromethane	5.21E-10
Di-n-butylphthalate	1.30E-10
Dioxins/Furans (EPA TEFs)	1.79E-17
Heptachlor epoxide	1.25E-12
INORGANICS	
Aluminum	1.79E-09
Arsenic	3.54E-10
Boron	3.30E-09
Calcium	1.64E-08
Copper	3.45E-08
Molybdenum	6.41E-09
Tin	2.25E-10
Titanium	3.28E-10
Vanadium	1.64E-10
Zinc	8.65E-09

Table 7A-5

Partition Coefficients for Contaminants of Concern in Surface Water/Fish Ingestion Pathway

Pollutant	Partition Coefficient (Kp) (L/kg)
ORGANICS	
Benzoic Acid	7.41E+01
Bis(2-ethylhexyl)phthalate	4.07E+09
Butylbenzylphthalate	3.63E+05
Dibromochloromethane	1.74E+02
Di-n-butylphthalate	3.98E+05
Dioxins/Furans (EPA TEFs)	1.26E+06
Heptachlor epoxide	2.51E+05
INORGANICS	
Aluminum	9.00E+04
Arsenic	9.00E+04
Boron	9.00E+04
Calcium	4.00E+05
Copper	2.00E+05
Molybdenum	NA
Tin	2.00E+05
Titanium	4.00E+05
Vanadium	4.00E+05
Zinc	2.00E+05

NA - Not available.

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DERIVATION OF SOIL POLLUTANT CONCENTRATIONS

APPENDIX 8A

DERIVATION OF SOIL POLLUTANT CONCENTRATIONS

This appendix presents a detailed discussion of the methods used to determine the soil pollutant concentrations. These values were used to determine exposure through the soil pathway.

Pollutant levels in soil were calculated for those pollutants, identified in Section 7, to be of concern through the soil pathway. They include semi-volatile organics, trace metals predicted to increase in the soil by 1% or more of the background concentration, and trace metals that are potential oral carcinogens. Soil pollutant levels were calculated based on deposition over a 2-year period. It was assumed that all pollutant levels in the soil are unaffected by degradation or other loss processes. Although in reality, the soil concentrations of many of the organics will decline over time due to degradation, this was not evaluated since it is possible that in some cases, degradation products may be more toxic than or of similar toxicity to the parent compounds. Since adequate information is not available with which to evaluate the production, fate, and toxicity of all potential degradation products for the organics, degradation was not evaluated.

The equations used to calculate soil contaminant concentrations are as follows:

Maximum Concentrations:

The formula for determining the maximum concentration of a pollutant in soil is:

$$C_{soil-max} = D_{total} \frac{1}{BD} \times \frac{1}{SD} \times T \times CF$$

Where:

$C_{soil\text{-}max}$	=	Maximum pollutant concentration in soil due to deposition (mg/kg).
D_{total}	=	Total deposition rate ($g/m^2/yr$).
T	=	Accumulation time (2 years), life of incinerator.
CF	=	Conversion factor (1,000 mg/g).
SD	=	Mixing depth of soil (0.1 or 0.2 meters).
BD	=	Bulk density of soil (1,425 kg/m^3).

The soil bulk density which was used (1,425 kg/m^3) was based on an average value from the various soil types that occur in the Rocky Mountain Arsenal vicinity (Price, 1990).

Average Concentrations:

Average soil pollutant concentrations that would occur over the 70-year lifetime of an individual were calculated as follows:

$$C_{soil\text{-}avg} = \frac{2\ years}{70\ years} \times \frac{C_{soil\text{-}max}}{2} + \frac{68\ years}{70\ years}\,(C_{soil\text{-}max})$$

Where:

$C_{soil\text{-}avg}$	=	Average pollutant concentration in soil due to deposition (mg/kg).
$C_{soil\text{-}max}$	=	Maximum pollutant concentration in soil due to deposition (mg/kg).

The first term in this equation accounts for the two years of deposition, and the second term accounts for the years following the facility lifetime.

Soil concentrations for all pollutants of concern were calculated for each of the exposure scenarios (i.e., Resident-A, Resident-B, Farmer, Worker) based on total deposition rates specific to each receptor location. Based on the selection of the routes of exposure under

the soil pathway, two mixing depths were used to calculate soil concentrations, 0.1 meter (10 cm) and 0.2 meter (20 cm).

Pollutant concentrations in soil determined for a 0.1-meter mixing depth were used in predicting exposure through the following routes of exposure:

- Exposure through child soil/dust ingestion.
- Exposure through child dermal absorption.
- Exposure through adult soil/dust ingestion.
- Exposure through adult dermal absorption.

For these exposure routes, the pollutants were assumed to be uniformly distributed in the top 0.1 meter of the soil.

Pollutant concentrations in soil established for a 0.2-meter mixing depth were used for the following routes of exposure:

- Exposure through vegetable consumption.
- Intake by cattle through grain, hay, and corn silage ingestion.

The 0.2-meter mixing depth was based on the assumption that only the top 0.2 meter (8 inches) of soil would be disturbed by disking or rototilling (EPA, 1986).

For all pollutants, maximum soil concentrations were used in estimating potential noncarcinogenic effects. Average soil concentrations were used in calculating carcinogenic risk for children and adults, since the calculation of carcinogenic risk is based on a 70-year lifetime exposure. Since infants are exposed for only 1 year during which exposure concentrations will be at a maximum, maximum soil concentrations were used in the calculation of carcinogenic risk to the infant.

Tables 8A-1 through 8A-4 present the pollutant concentrations in soil based on the Resident-A, Resident-B, Farmer, and Worker scenarios, respectively. It should be noted that the soil concentrations calculated for the Farmer scenario also were used in the Resident-A and Resident-B scenarios in estimating pollutant uptake through milk and beef consumption.

APPENDIX 8A

CITED REFERENCES

EPA (U.S. Environmental Protection Agency). 1986. Methodology for the Assessment of Health Risks Associated with Multiple Pathway Exposure to Municipal Waste Combustor Emissions, Draft. Environmental Criteria and Assessment Office, Cincinnati, OH.

Price, A. 1990. Personal Communication. Soil Conservation Service.

Table 8A-1

Soil Concentrations
Resident-A Scenario

	Total Deposition Rate (g/M2/yr)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil (mg/kg)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil .1M (mg/Kg)
ORGANICS					
Benzene	NA	NA	NA	NA	NA
Benzoic Acid	1.59E-07	1.10E-06	1.11E-06	2.20E-06	2.23E-06
Bis(2-ethylhexyl)phthalate	6.03E-08	4.17E-07	4.23E-07	8.34E-07	8.46E-07
Bromodichloromethane	NA	NA	NA	NA	NA
Butylbenzylphthalate	4.23E-08	2.93E-07	2.97E-07	5.86E-07	5.94E-07
Carbon Tetrachloride	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA
Dibromochloromethane	2.47E-08	1.71E-07	1.73E-07	3.42E-07	3.47E-07
Di-n-butylphthalate	9.05E-08	6.26E-07	6.35E-07	1.25E-06	1.27E-06
Diethylphthalate	8.00E-08	5.54E-07	5.62E-07	1.11E-06	1.12E-06
Dimethylphthalate	3.03E-08	2.10E-07	2.13E-07	4.20E-07	4.26E-07
Dioxins/Furans (EPA TEFs)	1.27E-14	8.81E-14	8.93E-14	1.76E-13	1.79E-13
Heptachlor epoxide	8.59E-10	5.94E-09	6.03E-09	1.19E-08	1.21E-08
Methyl Chloride	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA
Xylene	NA	NA	NA	NA	NA
INORGANICS					
Aluminum	NA	NA	NA	NA	NA
Antimony	6.37E-08	4.40E-07	4.47E-07	8.81E-07	8.93E-07
Arsenic	2.29E-07	1.59E-06	1.61E-06	3.17E-06	3.22E-06
Barium	NA	NA	NA	NA	NA
Boron	NA	NA	NA	NA	NA
Cadmium	1.17E-08	8.10E-08	8.22E-08	1.62E-07	1.64E-07
Calcium	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA
Copper	2.36E-05	1.63E-04	1.65E-04	3.26E-04	3.31E-04
Iron	NA	NA	NA	NA	NA
Lead	3.40E-07	2.35E-06	2.39E-06	4.70E-06	4.77E-06
Manganese	NA	NA	NA	NA	NA
Mercury	8.19E-07	5.66E-06	5.75E-06	1.13E-05	1.15E-05
Molybdenum	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Tin	NA	NA	NA	NA	NA
Titanium	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA

Table 8A-2

Soil Concentrations
Resident-B Scenario

	Total Deposition Rate (g/M2/yr)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil (mg/kg)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil .1M (mg/Kg)
ORGANICS					
Benzene	NA	NA	NA	NA	NA
Benzoic Acid	2.58E-07	1.78E-06	1.81E-06	3.57E-06	3.62E-06
Bis(2-ethylhexyl)phthalate	9.79E-08	6.77E-07	6.87E-07	1.35E-06	1.37E-06
Bromodichloromethane	NA	NA	NA	NA	NA
Butylbenzylphthalate	6.88E-08	4.76E-07	4.83E-07	9.51E-07	9.65E-07
Carbon Tetrachloride	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA
Dibromochloromethane	4.01E-08	2.77E-07	2.81E-07	5.55E-07	5.63E-07
Di-n-butylphthalate	1.47E-07	1.02E-06	1.03E-06	2.03E-06	2.06E-06
Diethylphthalate	1.30E-07	8.99E-07	9.12E-07	1.80E-06	1.82E-06
Dimethylphthalate	4.93E-08	3.41E-07	3.46E-07	6.82E-07	6.92E-07
Dioxins/Furans (EPA TEFs)	2.07E-14	1.43E-13	1.45E-13	2.86E-13	2.90E-13
Heptachlor epoxide	1.40E-09	9.65E-09	9.79E-09	1.93E-08	1.96E-08
Methyl Chloride	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA
Xylene	NA	NA	NA	NA	NA
INORGANICS					
Aluminum	NA	NA	NA	NA	NA
Antimony	1.03E-07	7.15E-07	7.26E-07	1.43E-06	1.45E-06
Arsenic	3.72E-07	2.58E-06	2.61E-06	5.15E-06	5.23E-06
Barium	NA	NA	NA	NA	NA
Boron	NA	NA	NA	NA	NA
Cadmium	1.90E-08	1.32E-07	1.34E-07	2.63E-07	2.67E-07
Calcium	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA
Copper	3.83E-05	2.65E-04	2.69E-04	5.30E-04	5.38E-04
Iron	NA	NA	NA	NA	NA
Lead	5.52E-07	3.82E-06	3.88E-06	7.64E-06	7.75E-06
Manganese	NA	NA	NA	NA	NA
Mercury	1.33E-06	9.20E-06	9.34E-06	1.84E-05	1.87E-05
Molybdenum	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Tin	NA	NA	NA	NA	NA
Titanium	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA

Table 8A-3

Soil Concentrations
Farmer Scenario

	Total Deposition Rate (g/M2/yr)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil (mg/kg)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil .1M (mg/Kg)
ORGANICS					
Benzene	NA	NA	NA	NA	NA
Benzoic Acid	1.54E-07	1.07E-06	1.08E-06	2.13E-06	2.16E-06
Bis(2-ethylhexyl)phthalate	5.85E-08	4.05E-07	4.11E-07	8.09E-07	8.21E-07
Bromodichloromethane	NA	NA	NA	NA	NA
Butylbenzylphthalate	4.11E-08	2.84E-07	2.88E-07	5.69E-07	5.77E-07
Carbon Tetrachloride	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA
Dibromochloromethane	2.40E-08	1.66E-07	1.68E-07	3.32E-07	3.36E-07
Di-n-butylphthalate	8.79E-08	6.08E-07	6.17E-07	1.22E-06	1.23E-06
Diethylphthalate	7.77E-08	5.37E-07	5.45E-07	1.07E-06	1.09E-06
Dimethylphthalate	2.95E-08	2.04E-07	2.07E-07	4.08E-07	4.13E-07
Dioxins/Furans (EPA TEFs)	1.24E-14	8.55E-14	8.67E-14	1.71E-13	1.73E-13
Heptachlor epoxide	8.34E-10	5.77E-09	5.85E-09	1.15E-08	1.17E-08
Methyl Chloride	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA
Xylene	NA	NA	NA	NA	NA
INORGANICS					
Aluminum	NA	NA	NA	NA	NA
Antimony	6.18E-08	4.27E-07	4.34E-07	8.55E-07	8.67E-07
Arsenic	2.23E-07	1.54E-06	1.56E-06	3.08E-06	3.12E-06
Barium	NA	NA	NA	NA	NA
Boron	NA	NA	NA	NA	NA
Cadmium	1.14E-08	7.86E-08	7.98E-08	1.57E-07	1.60E-07
Calcium	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA
Copper	2.29E-05	1.58E-04	1.61E-04	3.17E-04	3.21E-04
Iron	NA	NA	NA	NA	NA
Lead	3.30E-07	2.28E-06	2.32E-06	4.57E-06	4.63E-06
Manganese	NA	NA	NA	NA	NA
Mercury	7.95E-07	5.50E-06	5.58E-06	1.10E-05	1.12E-05
Molybdenum	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Tin	NA	NA	NA	NA	NA
Titanium	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA

Table 8A-4

Soil Concentrations
Worker Scenario

	Total Deposition Rate (g/M2/yr)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil (mg/kg)	Average Calculated Conc. in Soil (mg/Kg)	Maximum Calculated Conc. in Soil .1M (mg/Kg)
ORGANICS					
Benzene	NA	NA	NA	NA	NA
Benzoic Acid	2.29E-07	1.59E-06	1.61E-06	3.17E-06	3.22E-06
Bis(2-ethylhexyl)phthalate	8.70E-08	6.02E-07	6.10E-07	1.20E-06	1.22E-06
Bromodichloromethane	NA	NA	NA	NA	NA
Butylbenzylphthalate	6.11E-08	4.23E-07	4.29E-07	8.45E-07	8.58E-07
Carbon Tetrachloride	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA
Dibromochloromethane	3.56E-08	2.47E-07	2.50E-07	4.93E-07	5.00E-07
Di-n-butylphthalate	1.31E-07	9.04E-07	9.17E-07	1.81E-06	1.83E-06
Diethylphthalate	1.16E-07	7.99E-07	8.11E-07	1.60E-06	1.62E-06
Dimethylphthalate	4.38E-08	3.03E-07	3.07E-07	6.06E-07	6.15E-07
Dioxins/Furans (EPA TEFs)	1.84E-14	1.27E-13	1.29E-13	2.54E-13	2.58E-13
Heptachlor epoxide	1.24E-09	8.58E-09	8.70E-09	1.72E-08	1.74E-08
Methyl Chloride	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA
Xylene	NA	NA	NA	NA	NA
INORGANICS					
Aluminum	NA	NA	NA	NA	NA
Antimony	9.19E-08	6.36E-07	6.45E-07	1.27E-06	1.29E-06
Arsenic	3.31E-07	2.29E-06	2.32E-06	4.58E-06	4.64E-06
Barium	NA	NA	NA	NA	NA
Boron	NA	NA	NA	NA	NA
Cadmium	1.69E-08	1.17E-07	1.19E-07	2.34E-07	2.37E-07
Calcium	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA
Copper	3.40E-05	2.35E-04	2.39E-04	4.71E-04	4.78E-04
Iron	NA	NA	NA	NA	NA
Lead	4.91E-07	3.39E-06	3.44E-06	6.79E-06	6.89E-06
Manganese	NA	NA	NA	NA	NA
Mercury	1.18E-06	8.18E-06	8.29E-06	1.64E-05	1.66E-05
Molybdenum	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Tin	NA	NA	NA	NA	NA
Titanium	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA

APPENDIX 8B

METHODOLOGY FOR CALCULATING POLLUTANT CONCENTRATIONS IN VEGETABLES

APPENDIX 8B

METHODOLOGY FOR CALCULATING POLLUTANT CONCENTRATIONS IN VEGETABLES

This appendix presents a detailed discussion of the methods used to determine the pollutant concentrations in vegetables that are considered in the vegetable consumption exposure route. Three vegetables (carrots, lettuce, and tomatoes) were selected to represent the vegetables that may be grown in a household garden in the area surrounding the RMA.

8B.1 CARROTS

8B.1.1 General Approach

The pollutant concentration (C_u) in carrots resulting from uptake from the soil is expressed by the following equation:

$$C_u \text{ (mg/kg)} = \text{Pollutant concentration in soil (mg/kg)} \times \text{RUF}$$

Where:

RUF = Root uptake factor (unitless)

The soil concentrations used in the calculations are presented in Tables 8A-1, 8A-2, and 8A-3 for the Resident-A, Resident-B, and Farmer scenarios, respectively. The derivation of the root uptake factors is described in the following subsection.

8B.1.2 Derivation of Root Uptake Factors for Carrots

Organics

Root uptake factors (RUFs) were derived based on the work by Briggs et al. (1982). Briggs et al. (1982) studied the uptake of organic chemicals from solution by barley shoots and

established the following relationship between the root concentration factor (RCF) and the K_{ow} (octanol/water partition coefficient) for the organics tested:

$$\log (RCF - 0.82) = 0.77 \log K_{ow} - 1.52$$

Where:

$RCF = C_{root}/C_{solution}$

C_{root} = Pollutant concentration in the root (mg/kg).

$C_{solution}$ = Pollutant concentration in water (mg/L).

Given the following relationship between pollutant distributions in soil and water phases:

$$\frac{C_{soil}}{C_{solution}} = (K_{oc})\ (f_{oc})$$

Where:

C_{soil} = Pollutant concentration in soil (mg/kg).
$C_{solution}$ = Pollutant concentration in water (mg/L).
K_{oc} = Organic carbon partition coefficient.
f_{oc} = Fraction of organic carbon in the soil, 1.42 percent (Price, 1990).

The RUF for each compound could be determined from the RCF as shown in the following equation:

$$RUF = \frac{RCF}{(K_{oc})(f_{oc})} = \frac{C_{root}/C_{solution}}{C_{soil}/C_{solution}} = \frac{C_{root}}{C_{soil}}$$

RCFs and RUFs were calculated for the pollutants of concern using K_{ow}s and K_{oc}s from EPA (1986) and a soil organic carbon content (f_{oc}) of 1.42 percent (Price, 1990). Log K_{ow} and K_{oc} values used in the calculation of RUFs are presented in Table 8B-1. K_{oc} data were

not available for several chemicals. In these instances, the values were calculated based on the log K_{ow}. If the chemical was an aromatic with a log K_{ow} between 2 to 6.6, the following equation was used:

$$\log K_{oc} = 0.937 \log K_{ow} - 0.006 \text{ (Lyman et al., 1982)}$$

For aromatics with a log K_{ow} falling outside the given range, as well as all other organic substances, the following equation was used:

$$\log K_{oc} = 0.544 \log K_{ow} + 1.377 \text{ (Lyman et al., 1982).}$$

Inorganics

The RUFs used for the inorganic compounds were based on transfer coefficients developed by Baes et al. (1984) for tubers. Tubers are similar to carrots in that most tubers grow underground and serve as food storage organs. The transfer coefficients, which are expressed as dry weight plant concentrations divided by dry weight soil concentrations, were converted to wet weight by assuming a water content for carrots of 88 percent (Baes et al., 1984).

RUFs used to determine inorganic uptake by carrots can be found in Tables 8B-2 through 8B-7. It should be noted that, although the chemical composition of a plant reflects its growth medium, the rate of metals uptake by plants is highly variable and is influenced by many factors. These factors include parameters specific to the plant (species, age) and to the properties of the soil (pH, organic content, cation exchange capacity, concentration of other inorganics, temperature, aeration). Thus, in the absence of specific information regarding garden soil characteristics in the RMA area, the calculated RUFs should be viewed as best approximations.

Average concentrations of pollutants in carrots and average daily intakes are summarized for the adult and child for the Resident-A, Resident-B, and Farmer scenarios in Tables 8B-2, 8B-3, and 8B-4, respectively. The maximum pollutant concentration in carrots and the maximum daily intakes are summarized in Tables 8B-5, 8B-6, and 8B-7.

8B.2 TOMATOES AND LETTUCE

8B.2.1 Surface Deposition of Pollutants on Tomatoes and Lettuce

The plant pollutant concentration resulting from surface deposition (C_d) is expressed by the equation:

$$\underset{\text{(maximum)}}{C_d} = (DR)\,(VSDF)$$

$$\underset{\text{(average)}}{C_d} = (DR)\,(VSDF)\,(2/70)$$

Where:

DR = Pollutant dry deposition rate (mg/m^2s). This includes only dry deposition. Pollutants falling on plant surfaces from wet deposition are washed off the plant and incorporated into the soil.

VSDF = Vegetable surface deposition factor (m^2s/kg).

In calculating the average pollutant concentration from surface deposition, exposure duration was adjusted using a factor of 2/70. This factor is based on the assumption that pollutant deposition resulting from the 2 years of facility operation is averaged over a 70-year lifetime.

The VSDF is calculated according to the following equation (Holton et al., 1984):

$$VSDF = \frac{r\,(1 - e^{-kt})}{Yk}$$

Where:

r = Interception fraction of the plant (unitless) (Baes et al., 1984).
k = Total rate constant for degradation process (s^{-1}) (Baes et al., 1984).
t = Growing time(s) (Ells, 1990).
Y = Plant yield (wet weight) (kg/m^2) (Ennis, 1990).

The interception fraction refers to that fraction of the airborne material falling on a given growing area that is deposited upon (intercepted by) edible portions of the plant. The interception fractions used for lettuce (0.15) and tomatoes (0.068) are those computed by Baes et al. (1984) based on a theoretical model accounting for growth characteristics of the plants during their maturation in the field.

A number of degradation processes can affect the final concentrations of pollutants deposited on plant surfaces. These include weathering (mainly washoff by precipitation), volatilization, and photolysis. This analysis considered only weathering as a potential mechanism for loss of surface-deposited contamination. It was assumed that pollutants would remain sorbed to ash particles; therefore, only negligible amounts would undergo either volatilization or photolysis. Thus, the total rate constant for degradation processes (k) would be equal to the weathering loss removal constant (k_w). The weathering removal loss constant was calculated as follows (Baes et al., 1984):

$$k_w = \frac{\ln 2}{\text{half-life}} = 5.78 \times 10^{-7}\ s^{-1}$$

A half-life of 14 days (1.2×10^6 seconds), the value used by the U.S. Nuclear Regulatory Commission for particles (NCRP, 1984), was considered to be average for ash-bound pollutants. To be conservative, it was assumed in this assessment that no attenuation of surface contamination (e.g., by washing) takes place between the time the vegetables are harvested and eaten. The amount of a pollutant that can be removed by washing is highly

variable, depending partially on the extent the pollutant is sorbed to, or can penetrate, the leaf.

Growing times for vegetables in the area surrounding RMA were estimated to be approximately 45 days (3.89E+06 seconds) for tomatoes from fruit set until harvest and 65 days (5.62E+06 seconds) for lettuce from initial leaf formation to harvest time (Ells, 1990). Average crop yields for the RMA area were estimated to be approximately 1.34 kg/m^2 and 1.58 kg/m^2 for tomatoes and lettuce, respectively (Ennis, 1990).

The concentrations of pollutants in lettuce resulting from surface deposition are summarized in Tables 8B-8 through 8B-13 for the three exposure scenarios. The concentrations of pollutants in tomatoes resulting from surface deposition are summarized in Tables 8B-14 through 8B-19 for the three exposure scenarios.

8B.2.2 Plant Uptake of Pollutants by Tomatoes and Lettuce

The accumulation of pollutants in edible parts of plants as a result of uptake from the soil is dependent on two processes: root absorption and translocation to the edible portion.

In the case of the carrot, which is a modified taproot, the translocation distance is minimal, and the concentration predicted for the edible portion is essentially the root concentration (see preceding subsection). In the case of tomatoes and lettuce, where the edible portions (leaves in lettuce, fruit in tomatoes) are above ground, the potential for transport from the roots to the aerial portions of the plant also has to be considered.

The pollutant concentration (C_u) in the edible portions of tomato and lettuce plants resulting from uptake from the soil is expressed by the following equation:

$$C_u \text{ (mg/kg)} = \text{Pollutant concentration in soil (mg/kg) x PUF}$$

Where:

PUF = Plant uptake factor (unitless).

The potential for the translocation of pollutants to aboveground plant parts varies considerably with the nature of the pollutant and the plant. The subsection that follows addresses the translocation potentials for the pollutants of concern and derives uptake factors for those that might potentially accumulate at significant concentrations.

Organics

Travis and Arms (1988) presented the following relationship between the log K_{ow} and the plant uptake factor:

$$PUF = 38.9\ K_{ow}^{-0.58}$$

The uptake factors calculated by using the preceding equation were converted from dry weight to wet weight by assuming that lettuce and tomatoes have water contents of 95 and 94%, respectively (Baes et al., 1984).

The calculated PUFs for the pollutants of concern are presented in Tables 8B-8 through 8B-13 (lettuce) and Tables 8B-14 through 8B-19 (tomatoes).

Inorganics

The potential for the translocation of inorganics from roots to the aerial parts of the plants is influenced by numerous factors. These include the presence of chelating ligands (carriers), pH, oxidation-reduction state, competing cations, hydrolysis, polymerization, and the formation of insoluble salts (Kabata-Pendias and Pendias, 1985). However, a general

distinction can be made between those inorganics that are easily translocated and those that tend to remain in the roots.

The uptake factors used for the inorganic compounds in tomatoes are based on transfer coefficients developed by Baes et al. (1984) for fruit. Tomatoes, although commonly referred to as vegetables, are actually fruit. The uptake factors used for inorganics in lettuce are based on the transfer coefficients developed by Baes et al. (1984) for vegetative parts of plants, since the edible parts of the lettuce are the leaves. The coefficients developed by Baes et al. (1984) were converted from dry weight to wet weight by assuming that lettuce and tomatoes have water contents of 95 and 94%, respectively. The uptake factors for the inorganic compounds are presented in Tables 8B-8 through 8B-13 (lettuce) and Tables 8B-14 through 8B-19 (tomatoes).

Average concentrations of pollutants in lettuce and average daily intakes are summarized for the adult and child for the Resident-A, Resident-B, and the Farmer exposure scenarios in Tables 8B-8, 8B-9, and 8B-10, respectively. Maximum lettuce concentrations and maximum daily intakes are presented in Tables 8B-11, 8B-12, and 8B-13. Average concentrations of pollutants in tomatoes and average daily intakes are summarized for the adult and child for the Resident-A, Resident-B, and Farmer exposure scenarios in Tables 8B-14, 8B-15, and 8B-16, respectively. Maximum tomato concentrations and maximum daily intakes are presented in Tables 8B-17, 8B-18, and 8B-19.

APPENDIX 8B

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Table 8B-1

Log K_{ow}s and K_{oc}s

Organic Compounds	Log K_{ow}	Source	K_{oc}	Source
Bis(2-ethylhexyl)phthalate	9.61E+00	EPA, 1987	1.00E+04	Howard, 1989
Butylbenzylphthalate	5.80E+00	EPA, 1987	1.00E+01	Howard, 1989
Dibromochloromethane	2.24E+00	ATSDR, 1990a	8.30E+01	ATSDR, 1990a
Di-n-butylphthalate	5.60E+00	ATSDR, 1990b	1.69E+05	ATSDR, 1990a
Diethylphthalate	2.50E+00	EPA, 1986990	1.42E+02	EPA, 1986
Dimethylphthalate	2.21E+00	EPA, 1987	4.40E+01	Howard, 1989
Dioxins/Furans (EPA TEFs)	6.10E+00	EPA, 1989	3.30E+06	EPA, 1986
Heptachlor epoxide	5.40E-00	ATSDR, 1991	2.19E+03	ATSDR, 1991

Table 8B-2

Average Pollutant Concentration in Carrots, and Adult and Child Daily Intake at the Resident-A Location

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	log Kow	Koc	ROOT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	1.10E-06	1.87	248	4.69E-01	5.15E-07	4.99E-11	7.48E-11
Bis(2-ethylhexyl)phthalate	4.17E-07	9.61	10000	5.34E+03	2.23E-03	2.16E-07	3.23E-07
Butylbenzylphthalate	2.93E-07	5.8	68	9.15E+02	2.68E-04	2.60E-08	3.89E-08
Dibromochloromethane	1.71E-07	2.24	83	2.06E+00	3.51E-07	3.40E-11	5.10E-11
Di-n-butylphthalate	6.26E-07	5.6	169000	2.58E-01	1.62E-07	1.57E-11	2.35E-11
Diethylphthalate	5.54E-07	2.5	142	1.67E+00	9.23E-07	8.95E-11	1.34E-10
Dimethylphthalate	2.10E-07	2.21	44	3.74E+00	7.86E-07	7.62E-11	1.14E-10
Dioxins/Furans (EPA TEFs)	8.81E-14	6.10	3.30E+06	3.21E-02	2.83E-15	2.74E-19	4.10E-19
Heptachlor epoxide	5.94E-09	5.4	2190	1.40E+01	8.32E-08	8.06E-12	1.21E-11
INORGANICS							
Antimony	4.40E-07			3.60E-03	1.59E-09	1.54E-13	2.30E-13
Arsenic	1.59E-06			7.20E-04	1.14E-09	1.11E-13	1.66E-13
Cadmium	8.10E-08			1.80E-02	1.46E-09	1.41E-13	2.12E-13
Copper	1.63E-04			3.00E-02	4.89E-06	4.74E-10	7.10E-10
Mercury	5.66E-06			2.40E-02	1.36E-07	1.32E-11	1.97E-11

Table 8B-3

Average Pollutant Concentration in Carrots, and Adult and Child Daily Intake at the Resident-B Location

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	log Kow	Koc	ROOT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	1.78E-06	1.87	248	4.69E-01	8.37E-07	8.11E-11	1.22E-10
Bis(2-ethylhexyl)phthalate	6.77E-07	9.61	10000	5.34E+03	3.61E-03	3.50E-07	5.25E-07
Butylbenzylphthalate	4.76E-07	5.8	68	9.15E+02	4.35E-04	4.22E-08	6.32E-08
Dibromochloromethane	2.77E-07	2.24	83	2.06E+00	5.70E-07	5.53E-11	8.28E-11
Di-n-butylphthalate	1.02E-06	5.6	169000	2.58E-01	2.63E-07	2.55E-11	3.82E-11
Diethylphthalate	8.99E-07	2.5	142	1.67E+00	1.50E-06	1.45E-10	2.18E-10
Dimethylphthalate	3.41E-07	2.21	44	3.74E+00	1.28E-06	1.24E-10	1.85E-10
Dioxins/Furans (EPA TEFs)	1.43E-13	6.10	3.30E+06	3.21E-02	4.59E-15	4.45E-19	6.67E-19
Heptachlor epoxide	9.65E-09	5.4	2190	1.40E+01	1.35E-07	1.31E-11	1.96E-11
INORGANICS							
Antimony	7.15E-07			3.60E-03	2.58E-09	2.50E-13	3.74E-13
Arsenic	2.58E-06			7.20E-04	1.86E-09	1.80E-13	2.69E-13
Cadmium	1.32E-07			1.80E-02	2.37E-09	2.30E-13	3.44E-13
Copper	2.65E-04			3.00E-02	7.95E-06	7.71E-10	1.15E-09
Mercury	9.20E-06			2.40E-02	2.21E-07	2.14E-11	3.21E-11

Table 8B-4

Average Pollutant Concentration in Carrots, and Adult and Child Daily Intake at the Farmer Location

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	log Kow	Koc	ROOT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	1.07E-06	1.87	248	4.69E-01	5.00E-07	4.20E-10	9.03E-10
Bis(2-ethylhexyl)phthalate	4.05E-07	9.61	10000	5.34E+03	2.16E-03	1.81E-06	3.90E-06
Butylbenzylphthalate	2.84E-07	5.8	68	9.15E+02	2.60E-04	2.18E-07	4.70E-07
Dibromochloromethane	1.66E-07	2.24	83	2.06E+00	3.41E-07	2.86E-10	6.15E-10
Di-n-butylphthalate	6.08E-07	5.6	169000	2.58E-01	1.57E-07	1.32E-10	2.84E-10
Diethylphthalate	5.37E-07	2.5	142	1.67E+00	8.96E-07	7.52E-10	1.62E-09
Dimethylphthalate	2.04E-07	2.21	44	3.74E+00	7.63E-07	6.41E-10	1.38E-09
Dioxins/Furans (EPA TEFs)	8.55E-14	6.10	3.30E+06	3.21E-02	2.74E-15	2.30E-18	4.96E-18
Heptachlor epoxide	5.77E-09	5.4	2190	1.40E+01	8.08E-08	6.78E-11	1.46E-10
INORGANICS							
Antimony	4.27E-07			3.60E-03	1.54E-09	1.29E-12	2.78E-12
Arsenic	1.54E-06			7.20E-04	1.11E-09	9.31E-13	2.00E-12
Cadmium	7.86E-08			1.80E-02	1.42E-09	1.19E-12	2.56E-12
Copper	1.58E-04			3.00E-02	4.75E-06	3.99E-09	8.58E-09
Mercury	5.50E-06			2.40E-02	1.32E-07	1.11E-10	2.38E-10

Table 8B-5

Maximum Pollutant Concentration in Carrots, and Adult and Child Daily Intake at the Resident-A Location

	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	log Kow	Koc	ROOT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	1.11E-06	1.87	248	4.69E-01	5.23E-07	5.07E-11	7.59E-11
Bis(2-ethylhexyl)phthalate	4.23E-07	9.61	10000	5.34E+03	2.26E-03	2.19E-07	3.28E-07
Butylbenzylphthalate	2.97E-07	5.80	68	9.15E+02	2.72E-04	2.64E-08	3.95E-08
Dibromochloromethane	1.73E-07	2.24	83	2.06E+00	3.56E-07	3.45E-11	5.17E-11
Di-n-butylphthalate	6.35E-07	5.60	169000	2.58E-01	1.64E-07	1.59E-11	2.38E-11
Diethylphthalate	5.62E-07	2.50	142	1.67E+00	9.36E-07	9.08E-11	1.36E-10
Dimethylphthalate	2.13E-07	2.21	44	3.74E+00	7.97E-07	7.73E-11	1.16E-10
Dioxins/Furans (EPA TEFs)	8.93E-14	6.10	3.30E+06	3.21E-02	2.87E-15	2.78E-19	4.16E-19
Heptachlor epoxide	6.03E-09	5.40	2190	1.40E+01	8.44E-08	8.18E-12	1.23E-11
INORGANICS							
Antimony	4.47E-07			3.60E-03	1.61E-09	1.56E-13	2.33E-13
Arsenic	1.61E-06			7.20E-04	1.16E-09	1.12E-13	1.68E-13
Cadmium	8.22E-08			1.80E-02	1.48E-09	1.43E-13	2.15E-13
Copper	1.65E-04			3.00E-02	4.96E-06	4.81E-10	7.21E-10
Mercury	5.75E-06			2.40E-02	1.38E-07	1.34E-11	2.00E-11

Table 8B-6

Maximum Pollutant Concentration in Carrots, and Adult and Child Daily Intake at the Resident-B Location

	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	log Kow	Koc	ROOT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	1.81E-06	1.87	248	4.69E-01	8.49E-07	8.23E-11	1.23E-10
Bis(2-ethylhexyl)phthalate	6.87E-07	9.61	10000	5.34E+03	3.67E-03	3.56E-07	5.32E-07
Butylbenzylphthalate	4.83E-07	5.80	68	9.15E+02	4.42E-04	4.28E-08	6.41E-08
Dibromochloromethane	2.81E-07	2.24	83	2.06E+00	5.79E-07	5.61E-11	8.40E-11
Di-n-butylphthalate	1.03E-06	5.60	169000	2.58E-01	2.67E-07	2.59E-11	3.87E-11
Diethylphthalate	9.12E-07	2.50	142	1.67E+00	1.52E-06	1.47E-10	2.21E-10
Dimethylphthalate	3.46E-07	2.21	44	3.74E+00	1.30E-06	1.26E-10	1.88E-10
Dioxins/Furans (EPA TEFs)	1.45E-13	6.10	3.30E+06	3.21E-02	4.66E-15	4.52E-19	6.76E-19
Heptachlor epoxide	9.79E-09	5.40	2190	1.40E+01	1.37E-07	1.33E-11	1.99E-11
INORGANICS							
Antimony	7.26E-07			3.60E-03	2.61E-09	2.53E-13	3.79E-13
Arsenic	2.61E-06			7.20E-04	1.88E-09	1.82E-13	2.73E-13
Cadmium	1.34E-07			1.80E-02	2.40E-09	2.33E-13	3.49E-13
Copper	2.69E-04			3.00E-02	8.06E-06	7.82E-10	1.17E-09
Mercury	9.34E-06			2.40E-02	2.24E-07	2.17E-11	3.25E-11

Table 8B-7

Maximum Pollutant Concentration in Carrots, and Adult and Child Daily Intake at the Farmer Location

	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	log Kow	Koc	ROOT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	1.08E-06	1.87	248	4.69E-01	5.07E-07	4.26E-10	9.16E-10
Bis(2-ethylhexyl)phthalate	4.11E-07	9.61	10000	5.34E+03	2.19E-03	1.84E-06	3.96E-06
Butylbenzylphthalate	2.88E-07	5.80	68	9.15E+02	2.64E-04	2.22E-07	4.77E-07
Dibromochloromethane	1.68E-07	2.24	83	2.06E+00	3.46E-07	2.90E-10	6.24E-10
Di-n-butylphthalate	6.17E-07	5.60	169000	2.58E-01	1.59E-07	1.34E-10	2.88E-10
Diethylphthalate	5.45E-07	2.50	142	1.67E+00	9.09E-07	7.63E-10	1.64E-09
Dimethylphthalate	2.07E-07	2.21	44	3.74E+00	7.74E-07	6.50E-10	1.40E-09
Dioxins/Furans (EPA TEFs)	8.67E-14	6.10	3.30E+06	3.21E-02	2.78E-15	2.34E-18	5.03E-18
Heptachlor epoxide	5.85E-09	5.40	2190	1.40E+01	8.19E-08	6.88E-11	1.48E-10
INORGANICS							
Antimony	4.34E-07			3.60E-03	1.56E-09	1.31E-12	2.82E-12
Arsenic	1.56E-06			7.20E-04	1.12E-09	9.44E-13	2.03E-12
Cadmium	7.98E-08			1.80E-02	1.44E-09	1.21E-12	2.59E-12
Copper	1.61E-04			3.00E-02	4.82E-06	4.05E-09	8.70E-09
Mercury	5.58E-06			2.40E-02	1.34E-07	1.12E-10	2.42E-10

Table 8B-8

Average Pollutant Concentration in Lettuce, and Adult and Child Daily Intake at the Resident-A Location

	DRY DEPOSITION RATE g/M2/yr	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	AVERAGE CONC ON PLANT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	7.56E-08	1.10E-06	1.60E-01	1.76E-07	1.08E-08	1.87E-07	1.84E-11	8.66E-12
Bis(2-ethylhexyl)phthalate	2.87E-08	4.17E-07	5.19E-06	2.16E-12	4.10E-09	4.11E-09	4.05E-13	1.91E-13
Butylbenzylphthalate	2.01E-08	2.93E-07	8.41E-04	2.46E-10	2.88E-09	3.13E-09	3.09E-13	1.45E-13
Dibromochloromethane	1.17E-08	1.71E-07	9.77E-02	1.67E-08	1.68E-09	1.84E-08	1.81E-12	8.52E-13
Di-n-butylphthalate	4.31E-08	6.26E-07	1.10E-03	6.88E-10	6.17E-09	6.86E-09	6.76E-13	3.18E-13
Diethylphthalate	3.81E-08	5.54E-07	6.90E-02	3.82E-08	5.45E-09	4.37E-08	4.30E-12	2.03E-12
Dimethylphthalate	1.44E-08	2.10E-07	1.02E-01	2.13E-08	2.07E-09	2.34E-08	2.31E-12	1.09E-12
Dioxins/Furans (EPA TEFs)	6.06E-15	8.81E-14	5.64E-04	4.96E-17	8.67E-16	9.17E-16	9.04E-20	4.25E-20
Heptachlor epoxide	4.09E-10	5.94E-09	1.44E-03	8.53E-12	5.85E-11	6.70E-11	6.61E-15	3.11E-15
INORGANICS								
Antimony	3.03E-08	4.40E-07	1.00E-02	4.40E-09	4.34E-09	8.74E-09	8.62E-13	4.06E-13
Arsenic	1.09E-07	1.59E-06	2.00E-03	3.17E-09	1.56E-08	1.88E-08	1.85E-12	8.72E-13
Cadmium	5.57E-09	8.10E-08	5.50E-03	4.46E-10	7.98E-10	1.24E-09	1.23E-13	5.77E-14
Copper	1.12E-05	1.63E-04	2.00E-02	3.26E-06	1.61E-06	4.87E-06	4.80E-10	2.26E-10
Mercury	3.90E-07	5.66E-06	4.50E-02	2.55E-07	5.58E-08	3.11E-07	3.06E-11	1.44E-11

Table 8B-9

Average Pollutant Concentration in Lettuce, and Adult and Child Daily Intake at the Resident-B Location

	DRY DEPOSITION RATE g/M2/yr	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	AVERAGE CONC ON PLANT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	1.31E-08	1.78E-06	1.60E-01	2.86E-07	1.88E-09	2.88E-07	2.84E-11	1.33E-11
Bis(2-ethylhexyl)phthalate	4.97E-09	6.77E-07	5.19E-06	3.51E-12	7.12E-10	7.16E-10	7.06E-14	3.32E-14
Butylbenzylphthalate	3.49E-09	4.76E-07	8.41E-04	4.00E-10	5.00E-10	9.00E-10	8.88E-14	4.18E-14
Dibromochloromethane	2.04E-09	2.77E-07	9.77E-02	2.71E-08	2.92E-10	2.74E-08	2.70E-12	1.27E-12
Di-n-butylphthalate	7.47E-09	1.02E-06	1.10E-03	1.12E-09	1.07E-09	2.19E-09	2.16E-13	1.02E-13
Diethylphthalate	6.60E-09	8.99E-07	6.90E-02	6.21E-08	9.46E-10	6.30E-08	6.21E-12	2.92E-12
Dimethylphthalate	2.50E-09	3.41E-07	1.02E-01	3.47E-08	3.59E-10	3.50E-08	3.45E-12	1.63E-12
Dioxins/Furans (EPA TEFs)	1.05E-15	1.43E-13	5.64E-04	8.06E-17	1.50E-16	2.31E-16	2.28E-20	1.07E-20
Heptachlor epoxide	7.09E-11	9.65E-09	1.44E-03	1.39E-11	1.02E-11	2.40E-11	2.37E-15	1.11E-15
INORGANICS								
Antimony	5.25E-09	7.15E-07	1.00E-02	7.15E-09	7.52E-10	7.91E-09	7.79E-13	3.67E-13
Arsenic	1.89E-08	2.58E-06	2.00E-03	5.15E-09	2.71E-09	7.86E-09	7.75E-13	3.65E-13
Cadmium	9.66E-10	1.32E-07	5.50E-03	7.24E-10	1.38E-10	8.62E-10	8.50E-14	4.00E-14
Copper	1.95E-06	2.65E-04	2.00E-02	5.30E-06	2.79E-07	5.58E-06	5.50E-10	2.59E-10
Mercury	6.76E-08	9.20E-06	4.50E-02	4.14E-07	9.68E-09	4.24E-07	4.18E-11	1.97E-11

Table 8B-10

Average Pollutant Concentration in Lettuce, and Adult and Child Daily Intake at the Farmer Location

	DRY DEPOSITION RATE g/M2/yr	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	AVERAGE CONC ON PLANT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	2.60E-08	1.07E-06	1.60E-01	1.71E-07	3.72E-09	1.74E-07	2.67E-11	1.26E-11
Bis(2-ethylhexyl)phthalate	9.85E-09	4.05E-07	5.19E-06	2.10E-12	1.41E-09	1.41E-09	2.16E-13	1.02E-13
Butylbenzylphthalate	6.92E-09	2.84E-07	8.41E-04	2.39E-10	9.91E-10	1.23E-09	1.88E-13	8.85E-14
Dibromochloromethane	4.03E-09	1.66E-07	9.77E-02	1.62E-08	5.78E-10	1.68E-08	2.57E-12	1.21E-12
Di-n-butylphthalate	1.48E-08	6.08E-07	1.10E-03	6.68E-10	2.12E-09	2.79E-09	4.26E-13	2.01E-13
Diethylphthalate	1.31E-08	5.37E-07	6.90E-02	3.71E-08	1.87E-09	3.90E-08	5.96E-12	2.81E-12
Dimethylphthalate	4.96E-09	2.04E-07	1.02E-01	2.07E-08	7.10E-10	2.14E-08	3.28E-12	1.54E-12
Dioxins/Furans (EPA TEFs)	2.08E-15	8.55E-14	5.64E-04	4.82E-17	2.98E-16	3.46E-16	5.30E-20	2.49E-20
Heptachlor epoxide	1.40E-10	5.77E-09	1.44E-03	8.28E-12	2.01E-11	2.84E-11	4.34E-15	2.04E-15
INORGANICS								
Antimony	1.04E-08	4.27E-07	1.00E-02	4.27E-09	1.49E-09	5.76E-09	8.82E-13	4.15E-13
Arsenic	3.75E-08	1.54E-06	2.00E-03	3.08E-09	5.37E-09	8.45E-09	1.29E-12	6.08E-13
Cadmium	1.91E-09	7.86E-08	5.50E-03	4.33E-10	2.74E-10	7.07E-10	1.08E-13	5.09E-14
Copper	3.85E-06	1.58E-04	2.00E-02	3.17E-06	5.52E-07	3.72E-06	5.69E-10	2.68E-10
Mercury	1.34E-07	5.50E-06	4.50E-02	2.47E-07	1.92E-08	2.67E-07	4.08E-11	1.92E-11

Table 8B-11

Maximum Pollutant Concentration in Lettuce, and Adult and Child Daily Intake at the Resident-A Location

	DRY DEPOSITION RATE g/M2/yr	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC ON PLANT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	7.56E-08	1.11E-06	1.60E-01	1.78E-07	3.79E-07	5.57E-07	5.49E-11	2.58E-11
Bis(2-ethylhexyl)phthalate	2.87E-08	4.23E-07	5.19E-06	2.19E-12	1.44E-07	1.44E-07	1.42E-11	6.67E-12
Butylbenzylphthalate	2.01E-08	2.97E-07	8.41E-04	2.50E-10	1.01E-07	1.01E-07	9.98E-12	4.69E-12
Dibromochloromethane	1.17E-08	1.73E-07	9.77E-02	1.69E-08	5.89E-08	7.58E-08	7.47E-12	3.52E-12
Di-n-butylphthalate	4.31E-08	6.35E-07	1.10E-03	6.98E-10	2.16E-07	2.17E-07	2.14E-11	1.00E-11
Diethylphthalate	3.81E-08	5.62E-07	6.90E-02	3.88E-08	1.91E-07	2.30E-07	2.26E-11	1.07E-11
Dimethylphthalate	1.44E-08	2.13E-07	1.02E-01	2.16E-08	7.23E-08	9.40E-08	9.27E-12	4.36E-12
Dioxins/Furans (EPA TEFs)	6.06E-15	8.93E-14	5.64E-04	5.03E-17	3.04E-14	3.04E-14	3.00E-18	1.41E-18
Heptachlor epoxide	4.09E-10	6.03E-09	1.44E-03	8.65E-12	2.05E-09	2.06E-09	2.03E-13	9.54E-14
INORGANICS								
Antimony	3.03E-08	4.47E-07	1.00E-02	4.47E-09	1.52E-07	1.56E-07	1.54E-11	7.25E-12
Arsenic	1.09E-07	1.61E-06	2.00E-03	3.22E-09	5.47E-07	5.50E-07	5.42E-11	2.55E-11
Cadmium	5.57E-09	8.22E-08	5.50E-03	4.52E-10	2.79E-08	2.84E-08	2.80E-12	1.32E-12
Copper	1.12E-05	1.65E-04	2.00E-02	3.31E-06	5.62E-05	5.95E-05	5.87E-09	2.76E-09
Mercury	3.90E-07	5.75E-06	4.50E-02	2.59E-07	1.95E-06	2.21E-06	2.18E-10	1.03E-10

Table 8B-12

Maximum Pollutant Concentration in Lettuce, and Adult and Child Daily Intake at the Resident-B Location

	DRY DEPOSITION RATE g/M2/yr	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC ON PLANT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	1.31E-08	1.81E-06	1.60E-01	2.90E-07	6.57E-08	3.56E-07	3.51E-11	1.65E-11
Bis(2-ethylhexyl)phthalate	4.97E-09	6.87E-07	5.19E-06	3.56E-12	2.49E-08	2.49E-08	2.46E-12	1.16E-12
Butylbenzylphthalate	3.49E-09	4.83E-07	8.41E-04	4.06E-10	1.75E-08	1.79E-08	1.77E-12	8.31E-13
Dibromochloromethane	2.04E-09	2.81E-07	9.77E-02	2.75E-08	1.02E-08	3.77E-08	3.72E-12	1.75E-12
Di-n-butylphthalate	7.47E-09	1.03E-06	1.10E-03	1.13E-09	3.74E-08	3.86E-08	3.80E-12	1.79E-12
Diethylphthalate	6.60E-09	9.12E-07	6.90E-02	6.30E-08	3.31E-08	9.61E-08	9.47E-12	4.46E-12
Dimethylphthalate	2.50E-09	3.46E-07	1.02E-01	3.52E-08	1.26E-08	4.77E-08	4.70E-12	2.21E-12
Dioxins/Furans (EPA TEFs)	1.05E-15	1.45E-13	5.64E-04	8.18E-17	5.27E-15	5.35E-15	5.27E-19	2.48E-19
Heptachlor epoxide	7.09E-11	9.79E-09	1.44E-03	1.41E-11	3.55E-10	3.69E-10	3.64E-14	1.71E-14
INORGANICS								
Antimony	5.25E-09	7.26E-07	1.00E-02	7.26E-09	2.63E-08	3.36E-08	3.31E-12	1.56E-12
Arsenic	1.89E-08	2.61E-06	2.00E-03	5.23E-09	9.48E-08	1.00E-07	9.87E-12	4.64E-12
Cadmium	9.66E-10	1.34E-07	5.50E-03	7.34E-10	4.84E-09	5.58E-09	5.50E-13	2.59E-13
Copper	1.95E-06	2.69E-04	2.00E-02	5.38E-06	9.75E-06	1.51E-05	1.49E-09	7.02E-10
Mercury	6.76E-08	9.34E-06	4.50E-02	4.20E-07	3.39E-07	7.59E-07	7.48E-11	3.52E-11

Table 8B-13

Maximum Pollutant Concentration in Lettuce, and Adult and Child Daily Intake at the Farmer Location

	DRY DEPOSITION RATE g/M2/yr	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC ON PLANT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	2.60E-08	1.08E-06	1.60E-01	1.73E-07	1.30E-07	3.03E-07	4.64E-11	2.18E-11
Bis(2-ethylhexyl)phthalate	9.85E-09	4.11E-07	5.19E-06	2.13E-12	4.94E-08	4.94E-08	7.55E-12	3.55E-12
Butylbenzylphthalate	6.92E-09	2.88E-07	8.41E-04	2.43E-10	3.47E-08	3.49E-08	5.34E-12	2.51E-12
Dibromochloromethane	4.03E-09	1.68E-07	9.77E-02	1.64E-08	2.02E-08	3.66E-08	5.61E-12	2.64E-12
Di-n-butylphthalate	1.48E-08	6.17E-07	1.10E-03	6.78E-10	7.42E-08	7.48E-08	1.14E-11	5.39E-12
Diethylphthalate	1.31E-08	5.45E-07	6.90E-02	3.76E-08	6.56E-08	1.03E-07	1.58E-11	7.43E-12
Dimethylphthalate	4.96E-09	2.07E-07	1.02E-01	2.10E-08	2.49E-08	4.59E-08	7.02E-12	3.30E-12
Dioxins/Furans (EPA TEFs)	2.08E-15	8.67E-14	5.64E-04	4.89E-17	1.04E-14	1.05E-14	1.60E-18	7.54E-19
Heptachlor epoxide	1.40E-10	5.85E-09	1.44E-03	8.40E-12	7.04E-10	7.12E-10	1.09E-13	5.13E-14
INORGANICS								
Antimony	1.04E-08	4.34E-07	1.00E-02	4.34E-09	5.21E-08	5.65E-08	8.64E-12	4.07E-12
Arsenic	3.75E-08	1.56E-06	2.00E-03	3.12E-09	1.88E-07	1.91E-07	2.92E-11	1.37E-11
Cadmium	1.91E-09	7.98E-08	5.50E-03	4.39E-10	9.59E-09	1.00E-08	1.53E-12	7.22E-13
Copper	3.85E-06	1.61E-04	2.00E-02	3.21E-06	1.93E-05	2.25E-05	3.45E-09	1.62E-09
Mercury	1.34E-07	5.58E-06	4.50E-02	2.51E-07	6.71E-07	9.22E-07	1.41E-10	6.64E-11

Table 8B-14

Average Pollutant Concentration in Tomatoes, and Adult and Child Daily Intake at the Resident-A Location

	DRY DEPOSITION RATE g/M2/yr	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	AVERAGE CONC ON PLANT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	7.56E-08	1.10E-06	1.92E-01	2.11E-07	5.38E-09	2.16E-07	1.15E-10	2.72E-10
Bis(2-ethylhexyl)phthalate	2.87E-08	4.17E-07	6.23E-06	2.60E-12	2.04E-09	2.04E-09	1.08E-12	2.57E-12
Butylbenzylphthalate	2.01E-08	2.93E-07	1.01E-03	2.96E-10	1.43E-09	1.73E-09	9.17E-13	2.17E-12
Dibromochloromethane	1.17E-08	1.71E-07	1.17E-01	2.00E-08	8.36E-10	2.09E-08	1.11E-11	2.62E-11
Di-n-butylphthalate	4.31E-08	6.26E-07	1.32E-03	8.26E-10	3.07E-09	3.89E-09	2.06E-12	4.89E-12
Diethylphthalate	3.81E-08	5.54E-07	8.28E-02	4.58E-08	2.71E-09	4.86E-08	2.57E-11	6.11E-11
Dimethylphthalate	1.44E-08	2.10E-07	1.22E-01	2.56E-08	1.03E-09	2.66E-08	1.41E-11	3.35E-11
Dioxins/Furans (EPA TEFs)	6.06E-15	8.81E-14	6.76E-04	5.96E-17	4.31E-16	4.91E-16	2.60E-19	6.17E-19
Heptachlor epoxide	4.09E-10	5.94E-09	1.72E-03	1.02E-11	2.91E-11	3.93E-11	2.09E-14	4.95E-14
INORGANICS								
Antimony	3.03E-08	4.40E-07	1.80E-03	7.93E-10	2.16E-09	2.95E-09	1.56E-12	3.71E-12
Arsenic	1.09E-07	1.59E-06	3.60E-04	5.71E-10	7.77E-09	8.34E-09	4.42E-12	1.05E-11
Cadmium	5.57E-09	8.10E-08	9.00E-03	7.29E-10	3.97E-10	1.13E-09	5.97E-13	1.42E-12
Copper	1.12E-05	1.63E-04	1.50E-02	2.45E-06	7.99E-07	3.25E-06	1.72E-09	4.08E-09
Mercury	3.90E-07	5.66E-06	1.20E-02	6.80E-08	2.77E-08	9.57E-08	5.08E-11	1.20E-10

Table 8B-15

Average Pollutant Concentration in Tomatoes, and Adult and Child Daily Intake at the Resident-B Location

	DRY DEPOSITION RATE g/M2/yr	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	AVERAGE CONC ON PLANT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	1.31E-08	1.78E-06	1.92E-01	3.43E-07	9.33E-10	3.44E-07	1.82E-10	4.32E-10
Bis(2-ethylhexyl)phthalate	4.97E-09	6.77E-07	6.23E-06	4.22E-12	3.54E-10	3.58E-10	1.90E-13	4.51E-13
Butylbenzylphthalate	3.49E-09	4.76E-07	1.01E-03	4.80E-10	2.49E-10	7.29E-10	3.87E-13	9.17E-13
Dibromochloromethane	2.04E-09	2.77E-07	1.17E-01	3.25E-08	1.45E-10	3.27E-08	1.73E-11	4.11E-11
Di-n-butylphthalate	7.47E-09	1.02E-06	1.32E-03	1.34E-09	5.32E-10	1.87E-09	9.94E-13	2.36E-12
Diethylphthalate	6.60E-09	8.99E-07	8.28E-02	7.45E-08	4.70E-10	7.50E-08	3.97E-11	9.42E-11
Dimethylphthalate	2.50E-09	3.41E-07	1.22E-01	4.16E-08	1.78E-10	4.18E-08	2.22E-11	5.25E-11
Dioxins/Furans (EPA TEFs)	1.05E-15	1.43E-13	6.76E-04	9.67E-17	7.48E-17	1.72E-16	9.10E-20	2.16E-19
Heptachlor epoxide	7.09E-11	9.65E-09	1.72E-03	1.66E-11	5.05E-12	2.17E-11	1.15E-14	2.73E-14
INORGANICS								
Antimony	5.25E-09	7.15E-07	1.80E-03	1.29E-09	3.74E-10	1.66E-09	8.81E-13	2.09E-12
Arsenic	1.89E-08	2.58E-06	3.60E-04	9.28E-10	1.35E-09	2.28E-09	1.21E-12	2.86E-12
Cadmium	9.66E-10	1.32E-07	9.00E-03	1.18E-09	6.88E-11	1.25E-09	6.65E-13	1.58E-12
Copper	1.95E-06	2.65E-04	1.50E-02	3.97E-06	1.39E-07	4.11E-06	2.18E-09	5.17E-09
Mercury	6.76E-08	9.20E-06	1.20E-02	1.10E-07	4.81E-09	1.15E-07	6.11E-11	1.45E-10

Table 8B-16

Average Pollutant Concentration in Tomatoes, and Adult and Child Daily Intake at the Farmer Location

	DRY DEPOSITION RATE g/M2/yr	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	AVERAGE CONC ON PLANT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	2.60E-08	1.07E-06	1.92E-01	2.05E-07	1.85E-09	2.07E-07	1.70E-10	4.03E-10
Bis(2-ethylhexyl)phthalate	9.85E-09	4.05E-07	6.23E-06	2.52E-12	7.01E-10	7.04E-10	5.79E-13	1.37E-12
Butylbenzylphthalate	6.92E-09	2.84E-07	1.01E-03	2.87E-10	4.93E-10	7.80E-10	6.42E-13	1.52E-12
Dibromochloromethane	4.03E-09	1.66E-07	1.17E-01	1.94E-08	2.87E-10	1.97E-08	1.62E-11	3.85E-11
Di-n-butylphthalate	1.48E-08	6.08E-07	1.32E-03	8.02E-10	1.05E-09	1.86E-09	1.53E-12	3.62E-12
Diethylphthalate	1.31E-08	5.37E-07	8.28E-02	4.45E-08	9.31E-10	4.54E-08	3.74E-11	8.87E-11
Dimethylphthalate	4.96E-09	2.04E-07	1.22E-01	2.49E-08	3.53E-10	2.52E-08	2.07E-11	4.92E-11
Dioxins/Furans (EPA TEFs)	2.08E-15	8.55E-14	6.76E-04	5.78E-17	1.48E-16	2.06E-16	1.70E-19	4.02E-19
Heptachlor epoxide	1.40E-10	5.77E-09	1.72E-03	9.94E-12	1.00E-11	1.99E-11	1.64E-14	3.89E-14
INORGANICS								
Antimony	1.04E-08	4.27E-07	1.80E-03	7.69E-10	7.41E-10	1.51E-09	1.24E-12	2.95E-12
Arsenic	3.75E-08	1.54E-06	3.60E-04	5.54E-10	2.67E-09	3.22E-09	2.65E-12	6.29E-12
Cadmium	1.91E-09	7.86E-08	9.00E-03	7.08E-10	1.36E-10	8.44E-10	6.95E-13	1.65E-12
Copper	3.85E-06	1.58E-04	1.50E-02	2.38E-06	2.74E-07	2.65E-06	2.18E-09	5.17E-09
Mercury	1.34E-07	5.50E-06	1.20E-02	6.60E-08	9.53E-09	7.55E-08	6.21E-11	1.47E-10

Table 8B-17

Maximum Pollutant Concentration in Tomatoes, and Adult and Child Daily Intake at the Resident-A Location

	DRY DEPOSITION RATE g/M2/yr	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC ON PLANT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	7.56E-08	1.11E-06	1.92E-01	2.14E-07	1.88E-07	4.02E-07	2.13E-10	5.06E-10
Bis(2-ethylhexyl)phthalate	2.87E-08	4.23E-07	6.23E-06	2.63E-12	7.15E-08	7.15E-08	3.79E-11	8.98E-11
Butylbenzylphthalate	2.01E-08	2.97E-07	1.01E-03	3.00E-10	5.02E-08	5.05E-08	2.68E-11	6.35E-11
Dibromochloromethane	1.17E-08	1.73E-07	1.17E-01	2.03E-08	2.93E-08	4.96E-08	2.63E-11	6.23E-11
Di-n-butylphthalate	4.31E-08	6.35E-07	1.32E-03	8.38E-10	1.07E-07	1.08E-07	5.74E-11	1.36E-10
Diethylphthalate	3.81E-08	5.62E-07	8.28E-02	4.65E-08	9.49E-08	1.41E-07	7.50E-11	1.78E-10
Dimethylphthalate	1.44E-08	2.13E-07	1.22E-01	2.60E-08	3.60E-08	6.20E-08	3.29E-11	7.79E-11
Dioxins/Furans (EPA TEFs)	6.06E-15	8.93E-14	6.76E-04	6.04E-17	1.51E-14	1.52E-14	8.04E-18	1.91E-17
Heptachlor epoxide	4.09E-10	6.03E-09	1.72E-03	1.04E-11	1.02E-09	1.03E-09	5.46E-13	1.29E-12
INORGANICS								
Antimony	3.03E-08	4.47E-07	1.80E-03	8.04E-10	7.55E-08	7.63E-08	4.05E-11	9.59E-11
Arsenic	1.09E-07	1.61E-06	3.60E-04	5.79E-10	2.72E-07	2.72E-07	1.44E-10	3.43E-10
Cadmium	5.57E-09	8.22E-08	9.00E-03	7.40E-10	1.39E-08	1.46E-08	7.76E-12	1.84E-11
Copper	1.12E-05	1.65E-04	1.50E-02	2.48E-06	2.80E-05	3.04E-05	1.61E-08	3.83E-08
Mercury	3.90E-07	5.75E-06	1.20E-02	6.90E-08	9.71E-07	1.04E-06	5.51E-10	1.31E-09

Table 8B-18

Maximum Pollutant Concentration in Tomatoes, and Adult and Child Daily Intake at the Resident-B Location

	DRY DEPOSITION RATE g/M2/yr	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC ON PLANT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	1.31E-08	1.81E-06	1.92E-01	3.48E-07	3.27E-08	3.80E-07	2.02E-10	4.78E-10
Bis(2-ethylhexyl)phthalate	4.97E-09	6.87E-07	6.23E-06	4.28E-12	1.24E-08	1.24E-08	6.57E-12	1.56E-11
Butylbenzylphthalate	3.49E-09	4.83E-07	1.01E-03	4.87E-10	8.71E-09	9.20E-09	4.88E-12	1.16E-11
Dibromochloromethane	2.04E-09	2.81E-07	1.17E-01	3.30E-08	5.08E-09	3.81E-08	2.02E-11	4.79E-11
Di-n-butylphthalate	7.47E-09	1.03E-06	1.32E-03	1.36E-09	1.86E-08	2.00E-08	1.06E-11	2.51E-11
Diethylphthalate	6.60E-09	9.12E-07	8.28E-02	7.56E-08	1.65E-08	9.20E-08	4.88E-11	1.16E-10
Dimethylphthalate	2.50E-09	3.46E-07	1.22E-01	4.22E-08	6.24E-09	4.84E-08	2.57E-11	6.09E-11
Dioxins/Furans (EPA TEFs)	1.05E-15	1.45E-13	6.76E-04	9.81E-17	2.62E-15	2.72E-15	1.44E-18	3.42E-18
Heptachlor epoxide	7.09E-11	9.79E-09	1.72E-03	1.69E-11	1.77E-10	1.94E-10	1.03E-13	2.43E-13
INORGANICS								
Antimony	5.25E-09	7.26E-07	1.80E-03	1.31E-09	1.31E-08	1.44E-08	7.64E-12	1.81E-11
Arsenic	1.89E-08	2.61E-06	3.60E-04	9.41E-10	4.72E-08	4.81E-08	2.55E-11	6.05E-11
Cadmium	9.66E-10	1.34E-07	9.00E-03	1.20E-09	2.41E-09	3.61E-09	1.91E-12	4.54E-12
Copper	1.95E-06	2.69E-04	1.50E-02	4.03E-06	4.85E-06	8.88E-06	4.71E-09	1.12E-08
Mercury	6.76E-08	9.34E-06	1.20E-02	1.12E-07	1.68E-07	2.80E-07	1.49E-10	3.53E-10

Table 8B-19

Maximum Pollutant Concentration in Tomatoes, and Adult and Child Daily Intake at the Farmer Location

	DRY DEPOSITION RATE g/M2/yr	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC ON PLANT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS								
Benzoic Acid	2.60E-08	1.08E-06	1.92E-01	2.08E-07	6.47E-08	2.73E-07	2.24E-10	5.32E-10
Bis(2-ethylhexyl)phthalate	9.85E-09	4.11E-07	6.23E-06	2.56E-12	2.45E-08	2.45E-08	2.02E-11	4.79E-11
Butylbenzylphthalate	6.92E-09	2.88E-07	1.01E-03	2.91E-10	1.72E-08	1.75E-08	1.44E-11	3.42E-11
Dibromochloromethane	4.03E-09	1.68E-07	1.17E-01	1.97E-08	1.01E-08	2.98E-08	2.45E-11	5.81E-11
Di-n-butylphthalate	1.48E-08	6.17E-07	1.32E-03	8.13E-10	3.69E-08	3.77E-08	3.10E-11	7.35E-11
Diethylphthalate	1.31E-08	5.45E-07	8.28E-02	4.52E-08	3.26E-08	7.78E-08	6.40E-11	1.52E-10
Dimethylphthalate	4.96E-09	2.07E-07	1.22E-01	2.52E-08	1.24E-08	3.76E-08	3.09E-11	7.33E-11
Dioxins/Furans (EPA TEFs)	2.08E-15	8.67E-14	6.76E-04	5.87E-17	5.19E-15	5.24E-15	4.32E-18	1.02E-17
Heptachlor epoxide	1.40E-10	5.85E-09	1.72E-03	1.01E-11	3.50E-10	3.60E-10	2.96E-13	7.02E-13
INORGANICS								
Antimony	1.04E-08	4.34E-07	1.80E-03	7.81E-10	2.59E-08	2.67E-08	2.20E-11	5.21E-11
Arsenic	3.75E-08	1.56E-06	3.60E-04	5.62E-10	9.34E-08	9.40E-08	7.73E-11	1.83E-10
Cadmium	1.91E-09	7.98E-08	9.00E-03	7.18E-10	4.77E-09	5.49E-09	4.52E-12	1.07E-11
Copper	3.85E-06	1.61E-04	1.50E-02	2.41E-06	9.60E-06	1.20E-05	9.89E-09	2.34E-08
Mercury	1.34E-07	5.58E-06	1.20E-02	6.69E-08	3.34E-07	4.01E-07	3.30E-10	7.81E-10

APPENDIX 8C

METHODOLOGY FOR DETERMINING POLLUTANT UPTAKE THROUGH MILK AND BEEF CONSUMPTION

APPENDIX 8C

METHODOLOGY FOR DETERMINING POLLUTANT UPTAKE THROUGH MILK AND BEEF CONSUMPTION

8C.1 INTRODUCTION

The calculation of pollutant intakes via the consumption of dairy and beef products involves a number of steps:

- Calculation of the pollutant concentration in locally grown cattle feed resulting from surface deposition and uptake from contaminated soil.
- Calculation of the concentration of the pollutant in the products (milk, beef).
- Prediction of daily intake of dairy and beef products by humans.

This appendix will address all of these issues.

8C.2 CONCENTRATIONS RESULTING FROM PLANT UPTAKE

The methodology used in calculating pollutant concentrations in cattle feed through plant uptake from soil was the same as that described for garden vegetables, and is described by the equation:

$$C_{plant} = (C_{soil})\ (PUF)$$

Where:

C_{plant} = Pollutant concentration in plant resulting from root uptake (mg/kg).

C_{soil} = Pollutant concentration in soil (mg/kg).

PUF = Plant uptake factor, the ratio between pollutant concentration in soil and plant (unitless).

It was assumed that hay, grain, and corn are grown in fields that are regularly tilled; therefore, soil pollutant concentrations were based on a 20-cm mixing depth. The contaminant soil concentrations are based on deposition at the Farmer scenario location over the 2-year life of the incinerator and are calculated as described in Appendix 8A. As discussed in Subsection 8.1.1, for all scenarios, a farm is assumed to be located in the area of highest deposition and air concentration where cows were observed grazing.

8C.2.1 Inorganics

Plant uptake factors were derived for antimony, arsenic, cadmium, copper, and mercury. These are the inorganics that have been identified as contributing greater than 1% of background concentrations, or are potential oral carcinogens.

The uptake factors that were used for antimony in corn silage and hay were derived by dividing the antimony concentrations that have been reported in corn grain and grass, respectively, by a mean concentration for antimony reported in soils (Kabata-Pendias and Pendias, 1985). A transfer coefficient developed by Baes et al. (1984) for reproductive portions of plants was used as the uptake factor for antimony in grain.

The arsenic uptake factors for grain were based on data reported for barley grain, (Kabata-Pendias and Pendias, 1985). The uptake factors for arsenic by hay and corn are presented in NRCC (1978).

The cadmium uptake factor for grain was based on data reported for barley grains (Kabata-Pendias and Pendias, 1985). A transfer coefficient developed by Baes et al. (1984) for the vegetative portions of plants was used as the uptake factor for hay and

pasture grass; and a transfer coefficient developed for the reproductive portions of plants was used for corn silage.

For copper, uptake factors in hay and grain were based on data reported for pasture herbage and barley grain, respectively (Kabata-Pendias and Pendias, 1985). An uptake factor for corn silage was derived by dividing the mean copper concentration in corn grain by a mean soil concentration (Kabata-Pendias and Pendias, 1985).

Uptake factors for mercury in corn silage and hay were derived by dividing the mean mercury concentration in corn grain and alfalfa by a mean mercury concentration in soils (Kabata-Pendias and Pendias, 1985). A transfer coefficient for mercury developed for the reproductive parts of plants was used as an uptake factor for mercury in grain (Baes et al., 1984).

The uptake factors are presented in Tables 8C-1, 8C-2, and 8C-3 for grain, hay, and corn silage, respectively, along with pollutant concentrations for these feeds.

8C.2.2 Organics

Plant uptake factors for organic compounds were calculated using the same methodology as that described for tomatoes and lettuce, and are expressed by the following equation developed by Travis and Arms (1988):

$$PUF = 38.9\ K_{ow}^{-0.58}$$

8C.3 CONCENTRATION FROM SURFACE DEPOSITION

Surface deposition was evaluated for corn silage and hay. Since grain is protected by a husk, deposition was not evaluated for grain. The concentrations of pollutants in cattle

feed resulting from surface deposition (C_d) were calculated using equations similar to those used for lettuce and tomatoes in Appendix 8B:

$$C_d \text{ (maximum)} = (DR)(SDF)$$

$$C_d \text{ (average)} = (DR)(SDF)(2/70)$$

Where:

DR = Pollutant dry deposition rate (mg/m^2s). This includes only dry deposition. Pollutants falling on plant surfaces from wet deposition are washed off the plant and are incorporated into the soil.

SDF = Surface deposition factor (m^2s/kg).

In calculating the average pollutant concentration from surface deposition, the factor of 2/70 accounts for the 2 years of pollutant deposition from the facility that would occur over a 70-year lifetime of an individual.

The surface deposition factor was calculated using the following formula (Holton, 1984):

$$SDF\ (m^2s/kg) = \frac{r\,(1-e^{-kt})}{Yk}$$

Where:

r = Interception fraction of the plants (unitless) (Baes et al., 1984).

k = Total rate constant for degradation processes (s^{-1}) (Baes et al., 1984)

t = Growing time (s) (Ron Jepson, Adams County Agricultural Extension Agency, Personal Communication, 1990).

Y = Plant yield (dry weight) (kg/m^2).

Pollutant concentrations were determined in terms of dry weight. The dry weight productivity factors (plant yields) that were used were based on information from Ron Jepson (Adams County Agricultural Extension Agency, Personal Communication, 1990). The plant yield used for hay (0.35 kg/m^2) was based on one crop of alfalfa hay. The plant yield for one crop of corn silage was assumed to be 1.80 kg/m^2.

An interception fraction for hay was calculated using the following formula (Baes et al., 1984):

$$\text{Interception fraction} = 1 - e^{(-2.88Y)}$$

Where:

Y = Productivity in dry weight (kg/m^2).

Using the preceding productivity factor, an interception fraction of 0.635 was obtained for hay. An average interception fraction of 0.44 was used for corn silage (Baes et al., 1984).

As in the case of vegetable produce, only weathering was considered as a source of pollutant loss. The derivation of the weathering loss constant, $5.78 \times 10^{-7}s^{-1}$, is discussed in Appendix 8B.

A growing time of 4.5 weeks (2.72E+06 seconds) was assumed for one crop of alfalfa hay, and 130 days (1.12E+07 seconds) for one crop of corn silage (Ron Jepson, Adams County Agricultural Extension Agency, Personal Communication, 1990).

For the Resident-A, Resident-B, and Farmer scenarios, it was conservatively assumed that all hay, corn, and grain fed to the cattle were grown at the farm location. As

discussed in Subsection 8.1.1, for all scenarios, a farm is assumed to be located in the area of highest deposition and air concentration where cows were observed grazing.

8C.4 ESTIMATE OF POLLUTANT UPTAKE BY CATTLE

It was assumed that dairy cattle consume 22.45 kg (dry weight) of feed per day, and beef cattle consume 13 kg (dry weight) of feed per day (Dr. Tim Stanton, Colorado State University, Personal Communication, 1990). It was assumed that in the Rocky Mountain Arsenal area, a dairy cow's average diet consists of 55% grain, 17.5% corn silage, 17.5% hay, and 10% protein supplement. The average diet of beef cattle consists of 80% grain, 5% corn silage, 5% hay, and 10% protein supplement (derived from information provided by Dr. Tim Stanton, Colorado State University, Personal Communication, 1990). It was assumed that protein supplement is not exposed to pollutants in the area, and thus does not contribute to pollutants that cattle receive through their diet.

In addition, although some cattle in the area may graze, lactating dairy cattle and finishing stock do not graze, and thus, pasture grass and incidental soil ingested while grazing will not be evaluated.

The average pollutant concentration in the feed from all sources was calculated using the following general equation:

$$C_{feed} = [(C_{hay} \times DI_{hay}) + (C_{corn} \times DI_{corn}) + (C_{grain} \times DI_{grain})]/DI_{feed}$$

Where:

C_{feed} = Pollutant concentration in cattle feed, mg/kg.

C_{hay} = Pollutant concentration in hay, mg/kg.

DI_{hay} = Daily intake of hay, dry weight, kg/day.

C_{corn} = Pollutant concentration in corn silage, mg/kg.

DI_{corn} = Daily intake of corn silage, dry weight, kg/day.

C_{grain} = Pollutant concentration in grain, mg/kg.

DI_{grain} = Daily intake of grain, dry weight, kg/day.

DI_{feed} = DI_{hay} + DI_{corn} + DI_{grain}, kg/day.

The calculated average dairy cattle feed pollutant concentrations are presented for the Resident-A and Resident-B scenarios in Table 8C-4, and for the Farmer scenario in Table 8C-5. The maximum dairy cattle feed pollutant concentrations are presented in Tables 8C-6 and 8C-7. The calculated average beef cattle feed pollutant concentrations are presented in Tables 8C-8 and 8C-9, and the maximum beef cattle feed pollutant concentrations are presented in Tables 8C-10 and 8C-11.

8C.5 CALCULATION OF THE POLLUTANT CONCENTRATION IN FARM PRODUCTS

The pollutant concentration in beef and dairy products resulting from ingestion of hay, grain, and corn silage by beef and dairy cattle is calculated as follows:

$$C_{product} = C_{diet} \times DUF$$

Where:

$C_{product}$ = Pollutant concentration in farm product (milk, beef) (mg/kg).

C_{diet} = Average pollutant concentration in total animal diet (mg/kg).

DUF = Diet uptake factor, pollutant concentration ratio between farm product and feed. Specific to pollutant and product (unitless).

8C.5.1 Dioxins

The DUFs for dioxin were taken from current research that has investigated the feed/product pollutant relationship. Fries and Paustenbach (1990) reported a steady-state transfer ratio for dioxin of 5-to-1 between milk fat and dairy feed (dry weight), and between beef fat and cattle feed (dry weight). These DUFs were used to calculate dioxin concentrations in milk fat and beef fat.

8C.5.2 Other Pollutants

Concentrations for inorganics as well as all other organics were calculated in milk and beef. The DUFs for these pollutants were calculated by multiplying transfer coefficients (day/kg) by the daily feed intake, 22.45 kg/day (dairy cattle), and 13 kg/day (beef cattle). Transfer coefficients (TC) for the organics were derived using equations developed by Travis et al. (1988):

$$TC_{milk} = 10^{(-8.09 + \text{Log } K_{ow})}$$

$$TC_{beef} = 10^{(-7.6 + \text{Log } K_{ow})}$$

The log K_{ow} can be found in Appendix 8B, Table 8B-1.

Transfer coefficients for the inorganics were identified by Baes et al. (1984) for dairy and beef cattle.

The calculated pollutant concentrations in milk and milk fat as well as daily intakes are summarized in Tables 8C-4 and 8C-5 (average levels) and Tables 8C-6 and 8C-7 (maximum levels). Beef and beef fat pollutant concentrations and daily intakes are summarized in Tables 8C-8 and 8C-9 (average levels) and Tables 8C-10 and 8C-11 (maximum levels).

APPENDIX 8C

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Table 8C-1

Average and Maximum Pollutant Concentration in Grain at the Farm Location

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	PLANT UPTAKE FACTOR	AVERAGE CALCULATED CONC. IN GRAIN mg/Kg	MAXIMUM CALCULATED CONC. IN GRAIN mg/Kg
ORGANICS					
Benzoic Acid	1.07E-06	1.08E-06	3.20E+00	3.41E-06	3.46E-06
Bis(2-ethylhexyl)phthalate	4.05E-07	4.11E-07	1.04E-04	4.20E-11	4.26E-11
Butylbenzylphthalate	2.84E-07	2.88E-07	1.68E-02	4.78E-09	4.85E-09
Dibromochloromethane	1.66E-07	1.68E-07	1.95E+00	3.24E-07	3.29E-07
Di-n-butylphthalate	6.08E-07	6.17E-07	2.20E-02	1.34E-08	1.36E-08
Diethylphthalate	5.37E-07	5.45E-07	1.38E+00	7.42E-07	7.53E-07
Dimethylphthalate	2.04E-07	2.07E-07	2.03E+00	4.14E-07	4.20E-07
Dioxins/Furans (EPA TEFs)	8.55E-14	8.67E-14	1.13E-02	9.64E-16	9.78E-16
Heptachlor epoxide	5.77E-09	5.85E-09	2.87E-02	1.66E-10	1.68E-10
INORGANICS					
Antimony	4.27E-07	4.34E-07	3.00E-02	1.28E-08	1.30E-08
Arsenic	1.54E-06	1.56E-06	3.30E-03	5.08E-09	5.15E-09
Cadmium	7.86E-08	7.98E-08	1.00E-01	7.86E-09	7.98E-09
Copper	1.58E-04	1.61E-04	1.70E-01	2.69E-05	2.73E-05
Mercury	5.50E-06	5.58E-06	2.00E-01	1.10E-06	1.12E-06

Table 8C-2

Average and Maximum Pollutant Concentration in Hay at the Farm Location

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	DRY DEPOSITION RATE g/M2/yr	PLANT UPTAKE FACTOR	AVERAGE CONC. DUE TO UPTAKE mg/Kg	MAXIMUM CONC. DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	AVERAGE CALCULATED CONC IN HAY mg/Kg	MAXIMUM CALCULATED CONC IN HAY mg/Kg
ORGANICS										
Benzoic Acid	1.07E-06	1.08E-06	2.60E-08	3.20E+00	3.41E-06	3.46E-06	5.86E-08	2.05E-06	3.47E-06	5.51E-06
Bis(2-ethylhexyl)phthalate	4.05E-07	4.11E-07	9.85E-09	1.04E-04	4.20E-11	4.26E-11	2.22E-08	7.78E-07	2.23E-08	7.78E-07
Butylbenzylphthalate	2.84E-07	2.88E-07	6.92E-09	1.68E-02	4.78E-09	4.85E-09	1.56E-08	5.46E-07	2.04E-08	5.51E-07
Dibromochloromethane	1.66E-07	1.68E-07	4.03E-09	1.95E+00	3.24E-07	3.29E-07	9.11E-09	3.19E-07	3.33E-07	6.47E-07
Di-n-butylphthalate	6.08E-07	6.17E-07	1.48E-08	2.20E-02	1.34E-08	1.36E-08	3.34E-08	1.17E-06	4.68E-08	1.18E-06
Diethylphthalate	5.37E-07	5.45E-07	1.31E-08	1.38E+00	7.42E-07	7.53E-07	2.95E-08	1.03E-06	7.71E-07	1.79E-06
Dimethylphthalate	2.04E-07	2.07E-07	4.96E-09	2.03E+00	4.14E-07	4.20E-07	1.12E-08	3.92E-07	4.25E-07	8.12E-07
Dioxins/Furans (EPA TEFs)	8.55E-14	8.67E-14	2.08E-15	1.13E-02	9.64E-16	9.78E-16	4.70E-15	1.64E-13	5.66E-15	1.65E-13
Heptachlor epoxide	5.77E-09	5.85E-09	1.40E-10	2.87E-02	1.66E-10	1.68E-10	3.17E-10	1.11E-08	4.82E-10	1.13E-08
INORGANICS										
Antimony	4.27E-07	4.34E-07	1.04E-08	2.90E-02	1.24E-08	1.26E-08	2.35E-08	8.22E-07	3.59E-08	8.34E-07
Arsenic	1.54E-06	1.56E-06	3.75E-08	2.00E-01	3.08E-07	3.12E-07	8.46E-08	2.96E-06	3.93E-07	3.27E-06
Cadmium	7.86E-08	7.98E-08	1.91E-09	5.50E-01	4.33E-08	4.39E-08	4.32E-09	1.51E-07	4.76E-08	1.95E-07
Copper	1.58E-04	1.61E-04	3.85E-06	5.00E-01	7.92E-05	8.03E-05	8.70E-06	3.04E-04	8.79E-05	3.85E-04
Mercury	5.50E-06	5.58E-06	1.34E-07	2.30E-01	1.26E-06	1.28E-06	3.02E-07	1.06E-05	1.57E-06	1.19E-05

Table 8C-3

Average and Maximum Pollutant Concentration in Corn Silage at the Farm Location

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	DRY DEPOSITION RATE g/M2/yr	PLANT UPTAKE FACTOR	AVERAGE CONC.DUE TO UPTAKE mg/Kg	MAXIMUM CONC.DUE TO UPTAKE mg/Kg	AVERAGE CONC. ON PLANT SURFACE mg/Kg	MAXIMUM CONC. ON PLANT SURFACE mg/Kg	AVERAGE CALCULATED CONC IN CORN SILAGE mg/Kg	MAXIMUM CALCULATED CONC IN CORN SILAGE mg/Kg
ORGANICS										
Benzoic Acid	1.07E-06	1.08E-06	2.60E-08	3.20E+00	3.41E-06	3.46E-06	9.94E-09	3.48E-07	3.42E-06	3.81E-06
Bis(2-ethylhexyl)phthalate	4.05E-07	4.11E-07	9.85E-09	1.04E-04	4.20E-11	4.26E-11	3.77E-09	1.32E-07	3.81E-09	1.32E-07
Butylbenzylphthalate	2.84E-07	2.88E-07	6.92E-09	1.68E-02	4.78E-09	4.85E-09	2.65E-09	9.27E-08	7.43E-09	9.76E-08
Dibromochloromethane	1.66E-07	1.68E-07	4.03E-09	1.95E+00	3.24E-07	3.29E-07	1.55E-09	5.41E-08	3.25E-07	3.83E-07
Di-n-butylphthalate	6.08E-07	6.17E-07	1.48E-08	2.20E-02	1.34E-08	1.36E-08	5.67E-09	1.98E-07	1.90E-08	2.12E-07
Diethylphthalate	5.37E-07	5.45E-07	1.31E-08	1.38E+00	7.42E-07	7.53E-07	5.01E-09	1.75E-07	7.47E-07	9.28E-07
Dimethylphthalate	2.04E-07	2.07E-07	4.96E-09	2.03E+00	4.14E-07	4.20E-07	1.90E-09	6.65E-08	4.16E-07	4.87E-07
Dioxins/Furans (EPA TEFs)	8.55E-14	8.67E-14	2.08E-15	1.13E-02	9.64E-16	9.78E-16	7.97E-16	2.79E-14	1.76E-15	2.89E-14
Heptachlor epoxide	5.77E-09	5.85E-09	1.40E-10	2.87E-02	1.66E-10	1.68E-10	5.38E-11	1.88E-09	2.19E-10	2.05E-09
INORGANICS										
Antimony	4.27E-07	4.34E-07	1.04E-08	2.00E-03	8.55E-10	8.67E-10	3.98E-09	1.39E-07	4.84E-09	1.40E-07
Arsenic	1.54E-06	1.56E-06	3.75E-08	2.30E-01	3.54E-07	3.59E-07	1.44E-08	5.02E-07	3.69E-07	8.62E-07
Cadmium	7.86E-08	7.98E-08	1.91E-09	1.50E-01	1.18E-08	1.20E-08	7.33E-10	2.57E-08	1.25E-08	3.76E-08
Copper	1.58E-04	1.61E-04	3.85E-06	8.00E-02	1.27E-05	1.29E-05	1.48E-06	5.17E-05	1.41E-05	6.45E-05
Mercury	5.50E-06	5.58E-06	1.34E-07	2.20E-02	1.21E-07	1.23E-07	5.13E-08	1.79E-06	1.72E-07	1.92E-06

Table 8C-4

Average Pollutant Concentration in Milk for the Resident-A and Resident-B Scenarios

	AVERAGE CALCULATED CONC IN DIET (milk) mg/Kg	DIET UPTAKE MILK Unitless	TRANSFER COEFFICIENT MILK Day/Kg	AVERAGE CALCULATED CONC IN MILK mg/Kg	AVERAGE CALCULATED CONC IN MILK FAT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.09E-06		6.03E-07	4.17E-11		9.09E-15	5.25E-14
Bis(2-ethylhexyl)phthalate	4.59E-09		3.31E+01	3.41E-06		7.43E-10	4.29E-09
Butylbenzylphthalate	7.50E-09		5.13E-03	8.64E-10		1.88E-13	1.09E-12
Dibromochloromethane	2.93E-07		1.41E-06	9.30E-12		2.03E-15	1.17E-14
Di-n-butylphthalate	1.89E-08		3.24E-03	1.37E-09		2.99E-13	1.72E-12
Diethylphthalate	6.74E-07		2.57E-06	3.89E-11		8.47E-15	4.89E-14
Dimethylphthalate	3.75E-07		1.32E-06	1.11E-11		2.42E-15	1.40E-14
Dioxins/Furans (EPA TEFs)	1.83E-15	5.00E+00			9.14E-15	7.18E-20	4.72E-19
Heptachlor epoxide	2.14E-10		2.04E-03	9.80E-12		2.14E-15	1.23E-14
INORGANICS							
Antimony	1.42E-08		1.00E-04	3.18E-11		6.93E-15	4.00E-14
Arsenic	1.36E-07		6.00E-03	1.83E-08		3.99E-12	2.30E-11
Cadmium	1.48E-08		1.00E-03	3.33E-10		7.26E-14	4.19E-13
Copper	3.27E-05		1.50E-03	1.10E-06		2.40E-10	1.38E-09
Mercury	9.09E-07		4.50E-04	9.19E-09		2.00E-12	1.16E-11

Table 8C-5

Average Pollutant Concentration in Milk for the Farmer Scenario

	AVERAGE CALCULATED CONC IN DIET (milk) mg/Kg	DIET UPTAKE MILK Unitless	TRANSFER COEFFICIENT MILK Day/Kg	AVERAGE CALCULATED CONC IN MILK mg/Kg	AVERAGE CALCULATED CONC IN MILK FAT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.09E-06		6.03E-07	4.17E-11		1.82E-13	1.05E-12
Bis(2-ethylhexyl)phthalate	4.59E-09		3.31E+01	3.41E-06		1.49E-08	8.58E-08
Butylbenzylphthalate	7.50E-09		5.13E-03	8.64E-10		3.76E-12	2.17E-11
Dibromochloromethane	2.93E-07		1.41E-06	9.30E-12		4.05E-14	2.34E-13
Di-n-butylphthalate	1.89E-08		3.24E-03	1.37E-09		5.97E-12	3.45E-11
Diethylphthalate	6.74E-07		2.57E-06	3.89E-11		1.69E-13	9.78E-13
Dimethylphthalate	3.75E-07		1.32E-06	1.11E-11		4.84E-14	2.79E-13
Dioxins/Furans (EPA TEFs)	1.83E-15	5.00E+00			9.14E-15	1.44E-18	9.44E-18
Heptachlor epoxide	2.14E-10		2.04E-03	9.80E-12		4.27E-14	2.47E-13
INORGANICS							
Antimony	1.42E-08		1.00E-04	3.18E-11		1.39E-13	8.01E-13
Arsenic	1.36E-07		6.00E-03	1.83E-08		7.98E-11	4.61E-10
Cadmium	1.48E-08		1.00E-03	3.33E-10		1.45E-12	8.39E-12
Copper	3.27E-05		1.50E-03	1.10E-06		4.79E-09	2.77E-08
Mercury	9.09E-07		4.50E-04	9.19E-09		4.00E-11	2.31E-10

Table 8C-6

Maximum Pollutant Concentration in Milk for the Resident-A and Resident-B Scenarios

	MAXIMUM CALCULATED CONC IN DIET (milk) mg/Kg	DIET UPTAKE MILK Unitless	TRANSFER COEFFICIENT MILK Day/Kg	MAXIMUM CALCULATED CONC IN MILK mg/Kg	MAXIMUM CALCULATED CONC IN MILK FAT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.54E-06		6.03E-07	4.79E-11		1.04E-14	6.02E-14
Bis(2-ethylhexyl)phthalate	1.59E-07		3.31E+01	1.18E-04		2.58E-08	1.49E-07
Butylbenzylphthalate	1.16E-07		5.13E-03	1.34E-08		2.92E-12	1.68E-11
Dibromochloromethane	3.61E-07		1.41E-06	1.14E-11		2.49E-15	1.44E-14
Di-n-butylphthalate	2.51E-07		3.24E-03	1.83E-08		3.98E-12	2.30E-11
Diethylphthalate	8.89E-07		2.57E-06	5.13E-11		1.12E-14	6.45E-14
Dimethylphthalate	4.58E-07		1.32E-06	1.36E-11		2.96E-15	1.71E-14
Dioxins/Furans (EPA TEFs)	3.45E-14	5.00E+00			1.73E-13	1.36E-18	8.91E-18
Heptachlor epoxide	2.42E-09		2.04E-03	1.11E-10		2.42E-14	1.40E-13
INORGANICS							
Antimony	1.78E-07		1.00E-04	3.99E-10		8.69E-14	5.02E-13
Arsenic	7.26E-07		6.00E-03	9.78E-08		2.13E-11	1.23E-10
Cadmium	4.51E-08		1.00E-03	1.01E-09		2.21E-13	1.27E-12
Copper	9.36E-05		1.50E-03	3.15E-06		6.87E-10	3.97E-09
Mercury	3.02E-06		4.50E-04	3.05E-08		6.65E-12	3.84E-11

Table 8C-7

Maximum Pollutant Concentration in Milk for the Farmer Scenario

	MAXIMUM CALCULATED CONC IN DIET (milk) mg/Kg	DIET UPTAKE MILK Unitless	TRANSFER COEFFICIENT MILK Day/Kg	MAXIMUM CALCULATED CONC IN MILK mg/Kg	MAXIMUM CALCULATED CONC IN MILK FAT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.54E-06		6.03E-07	4.79E-11		2.09E-13	1.20E-12
Bis(2-ethylhexyl)phthalate	1.59E-07		3.31E+01	1.18E-04		5.16E-07	2.98E-06
Butylbenzylphthalate	1.16E-07		5.13E-03	1.34E-08		5.83E-11	3.37E-10
Dibromochloromethane	3.61E-07		1.41E-06	1.14E-11		4.99E-14	2.88E-13
Di-n-butylphthalate	2.51E-07		3.24E-03	1.83E-08		7.96E-11	4.60E-10
Diethylphthalate	8.89E-07		2.57E-06	5.13E-11		2.23E-13	1.29E-12
Dimethylphthalate	4.58E-07		1.32E-06	1.36E-11		5.91E-14	3.41E-13
Dioxins/Furans (EPA TEFs)	3.45E-14	5.00E+00			1.73E-13	2.71E-17	1.78E-16
Heptachlor epoxide	2.42E-09		2.04E-03	1.11E-10		4.84E-13	2.79E-12
INORGANICS							
Antimony	1.78E-07		1.00E-04	3.99E-10		1.74E-12	1.00E-11
Arsenic	7.26E-07		6.00E-03	9.78E-08		4.26E-10	2.46E-09
Cadmium	4.51E-08		1.00E-03	1.01E-09		4.41E-12	2.55E-11
Copper	9.36E-05		1.50E-03	3.15E-06		1.37E-08	7.93E-08
Mercury	3.02E-06		4.50E-04	3.05E-08		1.33E-10	7.69E-10

Table 8C-8

Average Pollutant Concentration in Beef for the Resident-A and Resident-B Scenarios

	AVERAGE CALCULATED CONC IN DIET (beef) mg/Kg	DIET UPTAKE BEEF Unitless	TRANSFER COEFFICIENT BEEF Day/Kg	AVERAGE CALCULATED CONC IN BEEF mg/Kg	AVERAGE CALCULATED CONC IN BEEFFAT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.08E-06		1.86E-06	7.43E-11		3.56E-15	8.87E-15
Bis(2-ethylhexyl)phthalate	1.34E-09		1.02E+02	1.78E-06		8.50E-11	2.12E-10
Butylbenzylphthalate	5.22E-09		1.58E-02	1.07E-09		5.13E-14	1.28E-13
Dibromochloromethane	2.92E-07		4.37E-06	1.65E-11		7.91E-16	1.97E-15
Di-n-butylphthalate	1.40E-08		1.00E-02	1.81E-09		8.68E-14	2.16E-13
Diethylphthalate	6.69E-07		7.94E-06	6.90E-11		3.30E-15	8.23E-15
Dimethylphthalate	3.74E-07		4.07E-06	1.97E-11		9.45E-16	2.36E-15
Dioxins/Furans (EPA TEFs)	1.14E-15	5.00E+00			5.71E-15	6.12E-20	1.66E-19
Heptachlor epoxide	1.68E-10		6.31E-03	1.37E-11		6.56E-16	1.64E-15
INORGANICS							
Antimony	1.23E-08		1.00E-03	1.59E-10		7.63E-15	1.90E-14
Arsenic	4.21E-08		2.00E-03	1.09E-09		5.23E-14	1.30E-13
Cadmium	9.30E-09		5.50E-04	6.63E-11		3.17E-15	7.92E-15
Copper	2.66E-05		1.00E-02	3.45E-06		1.65E-10	4.12E-10
Mercury	9.67E-07		2.50E-01	3.13E-06		1.50E-10	3.74E-10

Table 8C-9

Average Pollutant Concentration in Beef for the Farmer Scenario

	AVERAGE CALCULATED CONC IN DIET (beef) mg/Kg	DIET UPTAKE BEEF Unitless	TRANSFER COEFFICIENT BEEF Day/Kg	AVERAGE CALCULATED CONC IN BEEF mg/Kg	AVERAGE CALCULATED CONC IN BEEFFAT mg/Kg	ADULT AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	CHILD AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.08E-06		1.86E-06	7.43E-11		7.11E-14	1.77E-13
Bis(2-ethylhexyl)phthalate	1.34E-09		1.02E+02	1.78E-06		1.70E-09	4.24E-09
Butylbenzylphthalate	5.22E-09		1.58E-02	1.07E-09		1.03E-12	2.56E-12
Dibromochloromethane	2.92E-07		4.37E-06	1.65E-11		1.58E-14	3.95E-14
Di-n-butylphthalate	1.40E-08		1.00E-02	1.81E-09		1.74E-12	4.33E-12
Diethylphthalate	6.69E-07		7.94E-06	6.90E-11		6.60E-14	1.65E-13
Dimethylphthalate	3.74E-07		4.07E-06	1.97E-11		1.89E-14	4.71E-14
Dioxins/Furans (EPA TEFs)	1.14E-15	5.00E+00			5.71E-15	1.22E-18	3.32E-18
Heptachlor epoxide	1.68E-10		6.31E-03	1.37E-11		1.31E-14	3.27E-14
INORGANICS							
Antimony	1.23E-08		1.00E-03	1.59E-10		1.53E-13	3.81E-13
Arsenic	4.21E-08		2.00E-03	1.09E-09		1.05E-12	2.61E-12
Cadmium	9.30E-09		5.50E-04	6.63E-11		6.35E-14	1.58E-13
Copper	2.66E-05		1.00E-02	3.45E-06		3.31E-09	8.25E-09
Mercury	9.67E-07		2.50E-01	3.13E-06		3.00E-09	7.48E-09

Table 8C-10

Maximum Pollutant Concentration in Beef for the Resident-A and Resident-B Scenarios

	MAXIMUM CALCULATED CONC IN DIET (beef) mg/Kg	DIET UPTAKE BEEF Unitless	TRANSFER COEFFICIENT BEEF Day/Kg	MAXIMUM CALCULATED CONC IN BEEF mg/Kg	MAXIMUM CALCULATED CONC IN BEEFFAT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.24E-06		1.86E-06	7.82E-11		3.74E-15	9.33E-15
Bis(2-ethylhexyl)phthalate	4.55E-08		1.02E+02	6.04E-05		2.89E-09	7.21E-09
Butylbenzylphthalate	3.63E-08		1.58E-02	7.47E-09		3.57E-13	8.91E-13
Dibromochloromethane	3.14E-07		4.37E-06	1.78E-11		8.52E-16	2.12E-15
Di-n-butylphthalate	8.06E-08		1.00E-02	1.04E-08		5.00E-13	1.25E-12
Diethylphthalate	7.38E-07		7.94E-06	7.60E-11		3.64E-15	9.07E-15
Dimethylphthalate	4.01E-07		4.07E-06	2.12E-11		1.01E-15	2.53E-15
Dioxins/Furans (EPA TEFs)	1.05E-14	5.00E+00			5.25E-14	5.62E-19	1.52E-18
Heptachlor epoxide	8.00E-10		6.31E-03	6.54E-11		3.13E-15	7.81E-15
INORGANICS							
Antimony	5.91E-08		1.00E-03	7.67E-10		3.67E-14	9.15E-14
Arsenic	2.11E-07		2.00E-03	5.47E-09		2.62E-13	6.53E-13
Cadmium	1.80E-08		5.50E-04	1.29E-10		6.15E-15	1.53E-14
Copper	4.43E-05		1.00E-02	5.75E-06		2.75E-10	6.86E-10
Mercury	1.58E-06		2.50E-01	5.13E-06		2.45E-10	6.12E-10

Table 8C-11

Maximum Pollutant Concentration in Beef for the Farmer Scenario

	MAXIMUM CALCULATED CONC IN DIET (beef) mg/Kg	DIET UPTAKE BEEF Unitless	TRANSFER COEFFICIENT BEEF Day/Kg	MAXIMUM CALCULATED CONC IN BEEF mg/Kg	MAXIMUM CALCULATED CONC IN BEEFFAT mg/Kg	ADULT MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day	CHILD MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS							
Benzoic Acid	3.24E-06		1.86E-06	7.82E-11		7.48E-14	1.87E-13
Bis(2-ethylhexyl)phthalate	4.55E-08		1.02E+02	6.04E-05		5.78E-08	1.44E-07
Butylbenzylphthalate	3.63E-08		1.58E-02	7.47E-09		7.15E-12	1.78E-11
Dibromochloromethane	3.14E-07		4.37E-06	1.78E-11		1.70E-14	4.25E-14
Di-n-butylphthalate	8.06E-08		1.00E-02	1.04E-08		1.00E-11	2.49E-11
Diethylphthalate	7.38E-07		7.94E-06	7.60E-11		7.27E-14	1.81E-13
Dimethylphthalate	4.01E-07		4.07E-06	2.12E-11		2.03E-14	5.06E-14
Dioxins/Furans (EPA TEFs)	1.05E-14	5.00E+00			5.25E-14	1.12E-17	3.05E-17
Heptachlor epoxide	8.00E-10		6.31E-03	6.54E-11		6.26E-14	1.56E-13
INORGANICS							
Antimony	5.91E-08		1.00E-03	7.67E-10		7.34E-13	1.83E-12
Arsenic	2.11E-07		2.00E-03	5.47E-09		5.23E-12	1.31E-11
Cadmium	1.80E-08		5.50E-04	1.29E-10		1.23E-13	3.07E-13
Copper	4.43E-05		1.00E-02	5.75E-06		5.50E-09	1.37E-08
Mercury	1.58E-06		2.50E-01	5.13E-06		4.91E-09	1.22E-08

APPENDIX 8D

CALCULATION OF THE ESTIMATED DAILY INTAKE FOR THE SOIL/DUST INGESTION ROUTE OF EXPOSURE

Table 8D-1

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Soil/Dust Ingestion Route of Exposure Adult, Resident-A Scenario

	--------AVERAGE---------		--------MAXIMUM---------	
	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS				
Benzoic Acid	2.20E-06	3.14E-12	2.23E-06	3.18E-12
Bis(2-ethylhexyl)phthalate	8.34E-07	1.19E-12	8.46E-07	1.21E-12
Butylbenzylphthalate	5.86E-07	8.37E-13	5.94E-07	8.49E-13
Dibromochloromethane	3.42E-07	4.88E-13	3.47E-07	4.95E-13
Di-n-butylphthalate	1.25E-06	1.79E-12	1.27E-06	1.82E-12
Diethylphthalate	1.11E-06	1.58E-12	1.12E-06	1.60E-12
Dimethylphthalate	4.20E-07	6.00E-13	4.26E-07	6.08E-13
Dioxins/Furans (EPA TEFs)	1.76E-13	2.52E-19	1.79E-13	2.55E-19
Heptachlor epoxide	1.19E-08	1.70E-14	1.21E-08	1.72E-14
INORGANICS				
Antimony	8.81E-07	1.26E-12	8.93E-07	1.28E-12
Arsenic	3.17E-06	4.53E-12	3.22E-06	4.60E-12
Cadmium	1.62E-07	2.31E-13	1.64E-07	2.35E-13
Copper	3.26E-04	4.66E-10	3.31E-04	4.73E-10
Mercury	1.13E-05	1.62E-11	1.15E-05	1.64E-11

0.1 Soil ingestion rate (g/day)
70 Body weight (Kg)
365 days/yr
365000 g/Kg*day/yr

Table 8D-2

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Soil/Dust Ingestion Route of Exposure Adult, Resident-B Scenario

	AVERAGE		MAXIMUM	
	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS				
Benzoic Acid	3.57E-06	5.10E-12	3.62E-06	5.17E-12
Bis(2-ethylhexyl)phthalate	1.35E-06	1.93E-12	1.37E-06	1.96E-12
Butylbenzylphthalate	9.51E-07	1.36E-12	9.65E-07	1.38E-12
Dibromochloromethane	5.55E-07	7.93E-13	5.63E-07	8.04E-13
Di-n-butylphthalate	2.03E-06	2.91E-12	2.06E-06	2.95E-12
Diethylphthalate	1.80E-06	2.57E-12	1.82E-06	2.61E-12
Dimethylphthalate	6.82E-07	9.74E-13	6.92E-07	9.88E-13
Dioxins/Furans (EPA TEFs)	2.86E-13	4.09E-19	2.90E-13	4.15E-19
Heptachlor epoxide	1.93E-08	2.76E-14	1.96E-08	2.80E-14
INORGANICS				
Antimony	1.43E-06	2.04E-12	1.45E-06	2.07E-12
Arsenic	5.15E-06	7.36E-12	5.23E-06	7.47E-12
Cadmium	2.63E-07	3.76E-13	2.67E-07	3.81E-13
Copper	5.30E-04	7.57E-10	5.38E-04	7.68E-10
Mercury	1.84E-05	2.63E-11	1.87E-05	2.67E-11

0.1 Soil ingestion rate (g/day)
70 Body weight (Kg)
365 days/yr
365000 g/Kg*day/yr

Table 8D-3

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Soil/Dust Ingestion Route of Exposure Adult, Farmer Scenario

	AVERAGE		MAXIMUM	
	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS				
Benzoic Acid	2.13E-06	3.05E-12	2.16E-06	3.09E-12
Bis(2-ethylhexyl)phthalate	8.09E-07	1.16E-12	8.21E-07	1.17E-12
Butylbenzylphthalate	5.69E-07	8.12E-13	5.77E-07	8.24E-13
Dibromochloromethane	3.32E-07	4.74E-13	3.36E-07	4.81E-13
Di-n-butylphthalate	1.22E-06	1.74E-12	1.23E-06	1.76E-12
Diethylphthalate	1.07E-06	1.54E-12	1.09E-06	1.56E-12
Dimethylphthalate	4.08E-07	5.82E-13	4.13E-07	5.91E-13
Dioxins/Furans (EPA TEFs)	1.71E-13	2.44E-19	1.73E-13	2.48E-19
Heptachlor epoxide	1.15E-08	1.65E-14	1.17E-08	1.67E-14
INORGANICS				
Antimony	8.55E-07	1.22E-12	8.67E-07	1.24E-12
Arsenic	3.08E-06	4.40E-12	3.12E-06	4.46E-12
Cadmium	1.57E-07	2.25E-13	1.60E-07	2.28E-13
Copper	3.17E-04	4.52E-10	3.21E-04	4.59E-10
Mercury	1.10E-05	1.57E-11	1.12E-05	1.59E-11

0.1 Soil ingestion rate (g/day)
70 Body weight (Kg)
365 days/yr
365000 g/Kg*day/yr

Table 8D-4

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Soil/Dust Ingestion Route of Exposure Adult, Worker Scenario

	--------AVERAGE---------		--------MAXIMUM---------	
	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS				
Benzoic Acid	3.17E-06	2.79E-12	3.22E-06	2.83E-12
Bis(2-ethylhexyl)phthalate	1.20E-06	1.06E-12	1.22E-06	1.07E-12
Butylbenzylphthalate	8.45E-07	7.44E-13	8.58E-07	7.55E-13
Dibromochloromethane	4.93E-07	4.34E-13	5.00E-07	4.40E-13
Di-n-butylphthalate	1.81E-06	1.59E-12	1.83E-06	1.62E-12
Diethylphthalate	1.60E-06	1.41E-12	1.62E-06	1.43E-12
Dimethylphthalate	6.06E-07	5.34E-13	6.15E-07	5.41E-13
Dioxins/Furans (EPA TEFs)	2.54E-13	2.24E-19	2.58E-13	2.27E-19
Heptachlor epoxide	1.72E-08	1.51E-14	1.74E-08	1.53E-14
INORGANICS				
Antimony	1.27E-06	1.12E-12	1.29E-06	1.14E-12
Arsenic	4.58E-06	4.03E-12	4.64E-06	4.09E-12
Cadmium	2.34E-07	2.06E-13	2.37E-07	2.09E-13
Copper	4.71E-04	4.15E-10	4.78E-04	4.21E-10
Mercury	1.64E-05	1.44E-11	1.66E-05	1.46E-11

0.1 Soil ingestion rate (g/day)
70 Body weight (Kg)
225 days/yr
365000 g/Kg*day/yr

Table 8D-5

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Soil/Dust Ingestion Route of Exposure Child, Resident-A Scenario

	--------AVERAGE---------		--------MAXIMUM---------	
	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS				
Benzoic Acid	2.20E-06	2.84E-11	2.23E-06	2.88E-11
Bis(2-ethylhexyl)phthalate	8.34E-07	1.08E-11	8.46E-07	1.09E-11
Butylbenzylphthalate	5.86E-07	7.56E-12	5.94E-07	7.67E-12
Dibromochloromethane	3.42E-07	4.41E-12	3.47E-07	4.47E-12
Di-n-butylphthalate	1.25E-06	1.62E-11	1.27E-06	1.64E-11
Diethylphthalate	1.11E-06	1.43E-11	1.12E-06	1.45E-11
Dimethylphthalate	4.20E-07	5.42E-12	4.26E-07	5.50E-12
Dioxins/Furans (EPA TEFs)	1.76E-13	2.27E-18	1.79E-13	2.31E-18
Heptachlor epoxide	1.19E-08	1.53E-13	1.21E-08	1.56E-13
INORGANICS				
Antimony	8.81E-07	1.14E-11	8.93E-07	1.15E-11
Arsenic	3.17E-06	4.09E-11	3.22E-06	4.15E-11
Cadmium	1.62E-07	2.09E-12	1.64E-07	2.12E-12
Copper	3.26E-04	4.21E-09	3.31E-04	4.27E-09
Mercury	1.13E-05	1.46E-10	1.15E-05	1.48E-10

0.2 Soil/dust ingestion rate (g/day)
15.5 Body weight (Kg)
365 days/yr
365000 g/Kg*day/yr

Table 8D-6

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Soil/Dust Ingestion Route of Exposure Child, Resident-B Scenario

	--------AVERAGE---------		--------MAXIMUM---------	
	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS				
Benzoic Acid	3.57E-06	4.61E-11	3.62E-06	4.67E-11
Bis(2-ethylhexyl)phthalate	1.35E-06	1.75E-11	1.37E-06	1.77E-11
Butylbenzylphthalate	9.51E-07	1.23E-11	9.65E-07	1.25E-11
Dibromochloromethane	5.55E-07	7.16E-12	5.63E-07	7.26E-12
Di-n-butylphthalate	2.03E-06	2.63E-11	2.06E-06	2.66E-11
Diethylphthalate	1.80E-06	2.32E-11	1.82E-06	2.35E-11
Dimethylphthalate	6.82E-07	8.80E-12	6.92E-07	8.93E-12
Dioxins/Furans (EPA TEFs)	2.86E-13	3.69E-18	2.90E-13	3.75E-18
Heptachlor epoxide	1.93E-08	2.49E-13	1.96E-08	2.53E-13
INORGANICS				
Antimony	1.43E-06	1.85E-11	1.45E-06	1.87E-11
Arsenic	5.15E-06	6.65E-11	5.23E-06	6.75E-11
Cadmium	2.63E-07	3.40E-12	2.67E-07	3.45E-12
Copper	5.30E-04	6.84E-09	5.38E-04	6.94E-09
Mercury	1.84E-05	2.37E-10	1.87E-05	2.41E-10

0.2 Soil/dust ingestion rate (g/day)
15.5 Body weight (Kg)
365 days/yr
365000 g/Kg*day/yr

Table 8D-7

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Soil/Dust Ingestion Route of Exposure Child, Farmer Scenario

	AVERAGE		MAXIMUM	
	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day	C soil CALCULATED CONC IN SOIL .1M mg/Kg	EDI ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS				
Benzoic Acid	2.13E-06	2.75E-11	2.16E-06	2.79E-11
Bis(2-ethylhexyl)phthalate	8.09E-07	1.04E-11	8.21E-07	1.06E-11
Butylbenzylphthalate	5.69E-07	7.34E-12	5.77E-07	7.44E-12
Dibromochloromethane	3.32E-07	4.28E-12	3.36E-07	4.34E-12
Di-n-butylphthalate	1.22E-06	1.57E-11	1.23E-06	1.59E-11
Diethylphthalate	1.07E-06	1.39E-11	1.09E-06	1.41E-11
Dimethylphthalate	4.08E-07	5.26E-12	4.13E-07	5.34E-12
Dioxins/Furans (EPA TEFs)	1.71E-13	2.21E-18	1.73E-13	2.24E-18
Heptachlor epoxide	1.15E-08	1.49E-13	1.17E-08	1.51E-13
INORGANICS				
Antimony	8.55E-07	1.10E-11	8.67E-07	1.12E-11
Arsenic	3.08E-06	3.97E-11	3.12E-06	4.03E-11
Cadmium	1.57E-07	2.03E-12	1.60E-07	2.06E-12
Copper	3.17E-04	4.09E-09	3.21E-04	4.15E-09
Mercury	1.10E-05	1.42E-10	1.12E-05	1.44E-10

0.2 Soil/dust ingestion rate (g/day)
15.5 Body weight (Kg)
365 days/yr
365000 g/Kg*day/yr

APPENDIX 8E

CALCULATION OF THE ESTIMATED DAILY INTAKE FOR THE FISH INGESTION ROUTE OF EXPOSURE

APPENDIX 8E

CALCULATION OF THE ESTIMATED DAILY INTAKE FOR THE FISH INGESTION ROUTE OF EXPOSURE

The accumulation of substances in fish tissue involves the processes of bioconcentration and biomagnification. The bioconcentration of pollutants generally refers to the uptake of pollutants from water, primarily through passive transport across the gill membrane. Thus, the bioconcentration factor (BCF) describes the equilibrium between the pollutant concentration in the fish tissue and the pollutant concentration in the water. Bioaccumulation is similar to bioconcentration, however, bioaccumulation is a broader term that describes the uptake from both food and water (Clark et al., 1988). Biomagnification takes into account the relationship between the pollutant concentration in the fish tissue and the trophic transfer of pollutants. Thus, biomagnification refers to the accumulation of pollutants due to uptake of food through the food chain. Few data are presently available to verify pollutant uptake specific to biomagnification. Current investigations are attempting to address the contribution of biomagnification to total bioaccumulation (Connoly and Pedersen, 1988; McKay et al., 1986; Stevens, 1988). Most of the results are highly speculative.

Tissue pollutant concentrations increase until the rate of excretion is equal to the rate of uptake (i.e., a state of equilibrium is reached). At such a time, the body burden (fish tissue concentration) may be many times the concentration in the water. The BCF represents the ratio of pollutant concentration in tissue to the pollutant level in water at equilibrium.

BCFs were obtained for the pollutants of concern using the following procedure:

- The first step was to use BCFs currently recognized by the Environmental Protection Agency (EPA) for those pollutants of concern where available (EPA, 1989; 1987; 1986).

- If a BCF was not available through the EPA, additional sources (Verschueren, 1983; and Lyman et al., 1982) were searched for BCFs.

- For those organic chemicals for which no BCF was found, a BCF was calculated from the octanol-water partition coefficient (K_{ow}) using the following equation obtained from Lyman et al. (1982):

$$\log BCF = 0.76 \log K_{ow} - 0.23$$

There were six metals (aluminum, boron, calcium, molybdenum, tin, and titanium) for which BCFs were not available or could not be derived. However, the contribution of fish ingestion to the total carcinogenic risk was less than 1% for the various scenarios. In addition, the hazard indices are roughly 8 orders of magnitude below one. Therefore, even if the BCFs for these chemicals are high, it is anticipated that their contribution to risk would be minimal.

A summary of the BCFs used for the pollutants of concern is presented in Table 8E-1. This table also presents where the BCFs were obtained or how they were derived.

At best, BCFs are approximations made through laboratory experiments, field studies, correlations with physico-chemical factors such as octanol/water partition coefficients, and models based on pollutant biokinetics coupled with fish metabolism (EPA, 1986). Normally, bioconcentration studies determine the average pollutant uptake as a function of the entire fish. However, for the evaluation of human exposure, consumption is generally restricted to the edible portion of the fish (i.e., with head, tail, and visceral mass removed). For this assessment, consumption of filleted fish was assumed.

The organic pollutants present in the fish tissue are concentrated in lipids (fatty materials) found in those tissues. Thus, organic pollutant levels within the tissue are directly related to lipid concentration. A fillet lipid content of 10% was used to calculate adult and child estimated daily intakes of organic pollutants.

Table 8E-2 presents the surface water contaminant concentrations, BCFs, and adult and child estimated daily intakes for the fish ingestion pathway.

APPENDIX 8E

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Table 8E-1

Bioconcentration Factors (BCFs) Used for the Pollutants of Concern

Pollutant	BCF (L/kg)	Derivation[a]	References
ORGANICS			
Benzoic Acid	15.5	log K_{ow} (1.87)	Verschueren, 1983
Bis(2-ethylhexyl)phthalate	113	OR	EPA, 1980
Butylbenzylphthalate	663	OR	EPA, 1980
Dibromochloromethane	30	log K_{ow} (2.24)	ATSDR, 1990
Dioxins/Furans (EPA TEFs)	5,000	OR	EPA, 1986
Heptachlor Epoxide	14,400	OR	EPA, 1986
INORGANICS			
Aluminum	NTA	---	---
Arsenic	350	OR	EPA, 1989
Boron	NTA	---	---
Calcium	NTA	---	---
Copper	1,183	OR	EPA, 1989
Molybdenum	NTA	---	---
Tin	NTA	---	---
Titanium	NTA	---	---
Vanadium	10	OR	Lyman, et al., 1982
Zinc	578	OR	EPA, 1989

Key:

K_{ow} - Octanol-water partition coefficient
NTA - Not available
OR - BCF obtained directly from reference

[a]If a BCF could not be obtained from the EPA (1989, 1987, 1986) or other reference documents (Lyman, et al., 1982; Verschueren, 1983), a BCF was calculated, where appropriate, using values listed in this column as described in this appendix.

Table 8E-2

Daily Exposure to the Pollutants of Concern Through the Fish Ingestion Route of Exposure Adult and Child - Resident-A, Resident-B, and Farmer Scenarios

	SURFACE WATER CONCENTRAT. mg/L	BIO. CONC. FACTOR	ADULT ESTIMATED DAILY INTAKE mg/kg/day	CHILD ESTIMATED DAILY INTAKE mg/kg/day
ORGANICS				
Benzoic Acid	3.90E-09	15.5	4.18E-13	9.44E-13
Bis(2-ethylhexyl)phthalate	8.43E-11	113	6.59E-14	1.49E-13
Butylbenzylphthalate	6.01E-11	663	2.76E-13	6.22E-13
Dibromochloromethane	5.21E-10	30	1.08E-13	2.44E-13
Dioxins/Furans (EPA TEFs)	1.79E-17	5000	6.19E-19	1.40E-18
Heptachlor epoxide	1.25E-12	14400	1.24E-13	2.81E-13
INORGANICS				
Aluminum	1.79E-09		0.00E+00	0.00E+00
Arsenic	3.54E-10	350	8.57E-13	1.93E-12
Boron	3.30E-09		0.00E+00	0.00E+00
Calcium	1.64E-08		0.00E+00	0.00E+00
Copper	3.45E-08	1183	2.82E-10	6.37E-10
Molybdenum	6.41E-09		0.00E+00	0.00E+00
Tin	2.25E-10		0.00E+00	0.00E+00
Titanium	3.28E-10		0.00E+00	0.00E+00
Vanadium	1.64E-10	10	1.13E-14	2.56E-14
Zinc	8.65E-09	578	3.46E-11	7.81E-11

Percent body lipid in fillet (10%)
Adult fish ingestion rate (4.84 g/day)
Child fish ingestion rate (2.42 g/day)
Adult body weight (70 kg)
Child body weight (15.5 kg)

APPENDIX 8F

CALCULATION OF THE ESTIMATED DAILY INTAKE FOR THE DERMAL ABSORPTION ROUTE OF EXPOSURE

Table 8F-1

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Dermal Absorption Route of Exposure Adult, Resident-A Scenario

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	ABSORPTION FACTOR	AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS					
Benzoic Acid	1.10E-06	1.11E-06	1.00E-01	1.15E-12	1.17E-12
Bis(2-ethylhexyl)phthalate	4.17E-07	4.23E-07	1.00E-01	4.38E-13	4.44E-13
Butylbenzylphthalate	2.93E-07	2.97E-07	1.00E-01	3.08E-13	3.12E-13
Dibromochloromethane	1.71E-07	1.73E-07	1.00E-01	1.79E-13	1.82E-13
Di-n-butylphthalate	6.26E-07	6.35E-07	1.00E-01	6.58E-13	6.68E-13
Diethylphthalate	5.54E-07	5.62E-07	1.00E-01	5.82E-13	5.90E-13
Dimethylphthalate	2.10E-07	2.13E-07	1.00E-01	2.21E-13	2.24E-13
Dioxins/Furans (EPA TEFs)	8.81E-14	8.93E-14	1.00E-01	9.25E-20	9.39E-20
Heptachlor epoxide	5.94E-09	6.03E-09	1.00E-01	6.24E-15	6.34E-15
INORGANICS					
Antimony	4.40E-07	4.47E-07	1.00E-02	4.63E-14	4.69E-14
Arsenic	1.59E-06	1.61E-06	1.00E-02	1.67E-13	1.69E-13
Cadmium	8.10E-08	8.22E-08	1.00E-02	8.51E-15	8.64E-15
Copper	1.63E-04	1.65E-04	1.00E-02	1.71E-11	1.74E-11
Mercury	5.66E-06	5.75E-06	1.00E-02	5.95E-13	6.04E-13

117	Number of exposure events per year (events/yr)	NE
4500	Exposed surface area (cm2/event)	ESA
0.51	Skin adherence factor for soil (mg/cm2)	SAF
1	Soil matrix factor	SMF
70	Body weight (Kg)	BW
365	Days/yr	DAYR
1000000	mg/Kg	mgKg

Table 8F-2

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Dermal Absorption Route of Exposure Adult, Resident-B Scenario

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	ABSORPTION FACTOR	AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS					
Benzoic Acid	1.78E-06	1.81E-06	1.00E-01	1.88E-12	1.90E-12
Bis(2-ethylhexyl)phthalate	6.77E-07	6.87E-07	1.00E-01	7.12E-13	7.22E-13
Butylbenzylphthalate	4.76E-07	4.83E-07	1.00E-01	5.00E-13	5.07E-13
Dibromochloromethane	2.77E-07	2.81E-07	1.00E-01	2.92E-13	2.96E-13
Di-n-butylphthalate	1.02E-06	1.03E-06	1.00E-01	1.07E-12	1.08E-12
Diethylphthalate	8.99E-07	9.12E-07	1.00E-01	9.45E-13	9.59E-13
Dimethylphthalate	3.41E-07	3.46E-07	1.00E-01	3.58E-13	3.64E-13
Dioxins/Furans (EPA TEFs)	1.43E-13	1.45E-13	1.00E-01	1.50E-19	1.53E-19
Heptachlor epoxide	9.65E-09	9.79E-09	1.00E-01	1.01E-14	1.03E-14
INORGANICS					
Antimony	7.15E-07	7.26E-07	1.00E-02	7.52E-14	7.63E-14
Arsenic	2.58E-06	2.61E-06	1.00E-02	2.71E-13	2.75E-13
Cadmium	1.32E-07	1.34E-07	1.00E-02	1.38E-14	1.40E-14
Copper	2.65E-04	2.69E-04	1.00E-02	2.78E-11	2.82E-11
Mercury	9.20E-06	9.34E-06	1.00E-02	9.67E-13	9.81E-13

117	Number of exposure events per year (events/yr)	NE
4500	Exposed surface area (cm2/event)	ESA
0.51	Skin adherence factor for soil (mg/cm2)	SAF
1	Soil matrix factor	SMF
70	Body weight (Kg)	BW
365	Days/yr	DAYR
1000000	mg/Kg	mgKg

Table 8F-3

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Dermal Absorption Route of Exposure Adult, Farmer Scenario

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	ABSORPTION FACTOR	AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS					
Benzoic Acid	1.07E-06	1.08E-06	1.00E-01	5.50E-12	5.57E-12
Bis(2-ethylhexyl)phthalate	4.05E-07	4.11E-07	1.00E-01	2.08E-12	2.11E-12
Butylbenzylphthalate	2.84E-07	2.88E-07	1.00E-01	1.46E-12	1.49E-12
Dibromochloromethane	1.66E-07	1.68E-07	1.00E-01	8.54E-13	8.67E-13
Di-n-butylphthalate	6.08E-07	6.17E-07	1.00E-01	3.13E-12	3.18E-12
Diethylphthalate	5.37E-07	5.45E-07	1.00E-01	2.77E-12	2.81E-12
Dimethylphthalate	2.04E-07	2.07E-07	1.00E-01	1.05E-12	1.07E-12
Dioxins/Furans (EPA TEFs)	8.55E-14	8.67E-14	1.00E-01	4.40E-19	4.47E-19
Heptachlor epoxide	5.77E-09	5.85E-09	1.00E-01	2.97E-14	3.02E-14
INORGANICS					
Antimony	4.27E-07	4.34E-07	1.00E-02	2.20E-13	2.23E-13
Arsenic	1.54E-06	1.56E-06	1.00E-02	7.93E-13	8.05E-13
Cadmium	7.86E-08	7.98E-08	1.00E-02	4.05E-14	4.11E-14
Copper	1.58E-04	1.61E-04	1.00E-02	8.16E-11	8.28E-11
Mercury	5.50E-06	5.58E-06	1.00E-02	2.83E-12	2.87E-12

195	Number of exposure events per year (events/yr)	NE
4500	Exposed surface area (cm2/event)	ESA
1.5	Skin adherence factor for soil (mg/cm2)	SAF
1	Soil matrix factor	SMF
70	Body weight (Kg)	BW
365	Days/yr	DAYR
1000000	mg/Kg	mgKg

Table 8F-4

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Dermal Absorption Route of Exposure Adult, Worker Scenario

	AVERAGE CALCULATED CONC IN SOIL .2M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .2M mg/Kg	ABSORPTION FACTOR	AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS					
Benzoic Acid	1.59E-06	1.61E-06	1.00E-01	5.81E-12	5.89E-12
Bis(2-ethylhexyl)phthalate	6.02E-07	6.10E-07	1.00E-01	2.20E-12	2.24E-12
Butylbenzylphthalate	4.23E-07	4.29E-07	1.00E-01	1.55E-12	1.57E-12
Dibromochloromethane	2.47E-07	2.50E-07	1.00E-01	9.03E-13	9.16E-13
Di-n-butylphthalate	9.04E-07	9.17E-07	1.00E-01	3.31E-12	3.36E-12
Diethylphthalate	7.99E-07	8.11E-07	1.00E-01	2.93E-12	2.97E-12
Dimethylphthalate	3.03E-07	3.07E-07	1.00E-01	1.11E-12	1.13E-12
Dioxins/Furans (EPA TEFs)	1.27E-13	1.29E-13	1.00E-01	4.66E-19	4.72E-19
Heptachlor epoxide	8.58E-09	8.70E-09	1.00E-01	3.14E-14	3.19E-14
INORGANICS					
Antimony	6.36E-07	6.45E-07	1.00E-02	2.33E-13	2.36E-13
Arsenic	2.29E-06	2.32E-06	1.00E-02	8.39E-13	8.51E-13
Cadmium	1.17E-07	1.19E-07	1.00E-02	4.28E-14	4.35E-14
Copper	2.35E-04	2.39E-04	1.00E-02	8.62E-11	8.75E-11
Mercury	8.18E-06	8.29E-06	1.00E-02	3.00E-12	3.04E-12

195	Number of exposure events per year (events/yr)	NE
3200	Exposed surface area (cm2/event)	ESA
1.5	Skin adherence factor for soil (mg/cm2)	SAF
1	Soil matrix factor	SMF
70	Body weight (Kg)	BW
365	Days/yr	DAYR
1000000	mg/Kg	mgKg

Table 8F-5

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Dermal Absorption Route of Exposure Child, Resident-A Scenario

	AVERAGE CALCULATED CONC IN SOIL .1M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .1M mg/Kg	ABSORPTION FACTOR	AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS					
Benzoic Acid	2.20E-06	2.23E-06	1.00E-01	9.66E-12	9.80E-12
Bis(2-ethylhexyl)phthalate	8.34E-07	8.46E-07	1.00E-01	3.66E-12	3.72E-12
Butylbenzylphthalate	5.86E-07	5.94E-07	1.00E-01	2.57E-12	2.61E-12
Dibromochloromethane	3.42E-07	3.47E-07	1.00E-01	1.50E-12	1.52E-12
Di-n-butylphthalate	1.25E-06	1.27E-06	1.00E-01	5.50E-12	5.58E-12
Diethylphthalate	1.11E-06	1.12E-06	1.00E-01	4.87E-12	4.94E-12
Dimethylphthalate	4.20E-07	4.26E-07	1.00E-01	1.84E-12	1.87E-12
Dioxins/Furans (EPA TEFs)	1.76E-13	1.79E-13	1.00E-01	7.74E-19	7.85E-19
Heptachlor epoxide	1.19E-08	1.21E-08	1.00E-01	5.22E-14	5.30E-14
INORGANICS					
Antimony	8.81E-07	8.93E-07	1.00E-02	3.87E-13	3.93E-13
Arsenic	3.17E-06	3.22E-06	1.00E-02	1.39E-12	1.41E-12
Cadmium	1.62E-07	1.64E-07	1.00E-02	7.12E-14	7.22E-14
Copper	3.26E-04	3.31E-04	1.00E-02	1.43E-10	1.45E-10
Mercury	1.13E-05	1.15E-05	1.00E-02	4.98E-12	5.05E-12

195	Number of exposure events per year (events/yr.)	NE
2500	Exposed surface area (cm2/event)	ESA
0.51	Skin adherence factor for soil (mg/cm2)	SAF
1	Soil matrix factor	SMF
15.5	Body weight (Kg)	BW
365	Days/yr	DAYR
1000000	mg/Kg	mgKg

Table 8F-6

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Dermal Absorption Route of Exposure Child, Resident-B Scenario

	AVERAGE CALCULATED CONC IN SOIL .1M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .1M mg/Kg	ABSORPTION FACTOR	AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS					
Benzoic Acid	3.57E-06	3.62E-06	1.00E-01	1.57E-11	1.59E-11
Bis(2-ethylhexyl)phthalate	1.35E-06	1.37E-06	1.00E-01	5.95E-12	6.04E-12
Butylbenzylphthalate	9.51E-07	9.65E-07	1.00E-01	4.18E-12	4.24E-12
Dibromochloromethane	5.55E-07	5.63E-07	1.00E-01	2.44E-12	2.47E-12
Di-n-butylphthalate	2.03E-06	2.06E-06	1.00E-01	8.94E-12	9.07E-12
Diethylphthalate	1.80E-06	1.82E-06	1.00E-01	7.90E-12	8.02E-12
Dimethylphthalate	6.82E-07	6.92E-07	1.00E-01	3.00E-12	3.04E-12
Dioxins/Furans (EPA TEFs)	2.86E-13	2.90E-13	1.00E-01	1.26E-18	1.28E-18
Heptachlor epoxide	1.93E-08	1.96E-08	1.00E-01	8.48E-14	8.61E-14
INORGANICS					
Antimony	1.43E-06	1.45E-06	1.00E-02	6.29E-13	6.38E-13
Arsenic	5.15E-06	5.23E-06	1.00E-02	2.26E-12	2.30E-12
Cadmium	2.63E-07	2.67E-07	1.00E-02	1.16E-13	1.17E-13
Copper	5.30E-04	5.38E-04	1.00E-02	2.33E-10	2.36E-10
Mercury	1.84E-05	1.87E-05	1.00E-02	8.09E-12	8.21E-12

195	Number of exposure events per year (events/yr.)	NE
2500	Exposed surface area (cm2/event)	ESA
0.51	Skin adherence factor for soil (mg/cm2)	SAF
1	Soil matrix factor	SMF
15.5	Body weight (Kg)	BW
365	Days/yr	DAYR
1000000	mg/Kg	mgKg

Table 8F-7

Average and Maximum Daily Exposure to the Pollutants of Concern Through the Dermal Absorption Route of Exposure Child, Farmer Scenario

	AVERAGE CALCULATED CONC IN SOIL .1M mg/Kg	MAXIMUM CALCULATED CONC IN SOIL .1M mg/Kg	ABSORPTION FACTOR	AVERAGE ESTIMATED DAILY INTAKE mg/Kg/day	MAXIMUM ESTIMATED DAILY INTAKE mg/Kg/day
ORGANICS					
Benzoic Acid	2.13E-06	2.16E-06	1.00E-01	9.37E-12	9.51E-12
Bis(2-ethylhexyl)phthalate	8.09E-07	8.21E-07	1.00E-01	3.56E-12	3.61E-12
Butylbenzylphthalate	5.69E-07	5.77E-07	1.00E-01	2.50E-12	2.53E-12
Dibromochloromethane	3.32E-07	3.36E-07	1.00E-01	1.46E-12	1.48E-12
Di-n-butylphthalate	1.22E-06	1.23E-06	1.00E-01	5.34E-12	5.42E-12
Diethylphthalate	1.07E-06	1.09E-06	1.00E-01	4.72E-12	4.79E-12
Dimethylphthalate	4.08E-07	4.13E-07	1.00E-01	1.79E-12	1.82E-12
Dioxins/Furans (EPA TEFs)	1.71E-13	1.73E-13	1.00E-01	7.51E-19	7.62E-19
Heptachlor epoxide	1.15E-08	1.17E-08	1.00E-01	5.07E-14	5.14E-14
INORGANICS					
Antimony	8.55E-07	8.67E-07	1.00E-02	3.76E-13	3.81E-13
Arsenic	3.08E-06	3.12E-06	1.00E-02	1.35E-12	1.37E-12
Cadmium	1.57E-07	1.60E-07	1.00E-02	6.91E-14	7.01E-14
Copper	3.17E-04	3.21E-04	1.00E-02	1.39E-10	1.41E-10
Mercury	1.10E-05	1.12E-05	1.00E-02	4.83E-12	4.90E-12

195	Number of exposure events per year (events/yr.)	NE
2500	Exposed surface area (cm2/event)	ESA
0.51	Skin adherence factor for soil (mg/cm2)	SAF
1	Soil matrix factor	SMF
15.5	Body weight (Kg)	BW
365	Days/yr	DAYR
1000000	mg/Kg	mgKg

APPENDIX 8G

METHODOLOGY FOR CALCULATING ORGANIC POLLUTANT CONCENTRATIONS IN BREAST MILK

APPENDIX 8G

METHODOLOGY FOR CALCULATING ORGANIC POLLUTANT CONCENTRATIONS IN BREAST MILK

This appendix presents a discussion of the methods used to determine the organic pollutant concentrations in breast milk. These concentrations are used in the calculation of the daily intakes of pollutants by infants through the consumption of breast milk.

The concentration of dioxins in breast milk was calculated using the following equation that was developed for dioxins (Smith, 1987):

$$C_{DBMilk} = \frac{TEDI \times f_1 \times f_2}{f_3 \times k}$$

Where:

C_{DBMilk}	=	Concentration of dioxins in breast milk (mg/kg).
TEDI	=	Total Estimated Daily Intake, the maximum daily intake of dioxins by the mother through all potential exposure routes (mg/kg/day).
f_1	=	Proportion of dioxins stored in body fat (unitless).
f_2	=	Proportion of breast milk that is fat (unitless).
f_3	=	Proportion of body weight that is fat (unitless).
k	=	Rate constant ($days^{-1}$).

The maximum total estimated daily intake of the mother was used to estimate breast milk concentrations for dioxins as well as all other organics.

Values of 0.8, 0.04, and 0.3 were used for f_1, f_2, and f_3, respectively (Smith, 1987). Rate constants for the organic compounds were calculated using the following equation:

$$k = \frac{\ln 2}{t_{1/2}}$$

Tables 8G-1 through 8G-3 present pollutant concentrations in breast milk for the Resident-A, Resident-B, and Farmer scenarios, respectively.

APPENDIX 8G

CITED REFERENCES

ATSDR (Agency for Toxic Substances and Disease Registry). 1989e. *Toxicological Profile for 2,3,7,8-Tetrachlorodibenzo-p-dioxin*. Prepared by Syracuse Research Corporation. PB89-214522.

Baselt, R.C. 1982. *Disposition of Toxic Drugs and Chemicals in Man*. 2nd edition. Biomedical Publications, Davis, CA.

Smith, A. H. 1987. "Infant Exposure Assessment for Breast Milk Dioxins and Furans Derived from Waste Incineration Emissions," *Risk Analysis* 7(3):347-353.

Table 8G-1

Pollutant Concentrations in Breast Milk
Resident-A Scenario

	DI Maximum Total Daily Intake (mg/kg/day)	TF Breast Milk Transfer Factor (day)	Maximum Breast Milk Conc. (mg/kg)	Maximum Estimated Daily Intake (mg/kg/day)
ORGANICS				
Benzene	1.24E-09	1.92E-02	2.39E-11	2.13E-12
Benzoic Acid	5.48E-09	1.54E+01	8.43E-08	7.50E-09
Bis(2-ethylhexyl)phthalate	2.50E-07	7.70E-02	1.92E-08	1.71E-09
Bromodichloromethane	4.31E-09	3.85E-01	1.66E-09	1.47E-10
Butylbenzylphthalate	2.78E-08	1.54E+00	4.28E-08	3.80E-09
Carbon Tetrachloride	1.13E-09	3.85E-01	4.36E-10	3.88E-11
Chlorobenzene	1.10E-09	3.85E-01	4.24E-10	3.77E-11
Chloroform	1.97E-08	3.85E-01	7.56E-09	6.72E-10
Dibromochloromethane	8.70E-10	5.13E-01	4.47E-10	3.97E-11
Di-n-butylphthalate	3.04E-09	1.54E+00	4.68E-09	4.16E-10
Diethylphthalate	2.79E-09	1.54E+00	4.29E-09	3.81E-10
Dimethylphthalate	1.11E-09	1.54E+00	1.70E-09	1.51E-10
Dioxins/Furans (EPA TEFs)	4.27E-16	3.26E+02	1.39E-13	1.24E-14
Heptachlor epoxide	3.70E-11	1.54E+01	5.69E-10	5.06E-11
Methyl Chloride	1.41E-08	3.85E-01	5.44E-09	4.84E-10
Methylene Chloride	2.21E-09	3.85E-01	8.49E-10	7.55E-11
Styrene	1.06E-08	3.85E-01	4.09E-09	3.64E-10
Toluene	2.62E-09	4.81E-02	1.26E-10	1.12E-11
Xylene	1.08E-09	9.62E-03	1.04E-11	9.26E-13

Table 8G-2

Pollutant Concentrations in Breast Milk
Resident-B Scenario

	DI Maximum Total Daily Intake (mg/kg/day)	TF Breast Milk Transfer Factor (day)	Maximum Breast Milk Conc. (mg/kg)	Maximum Estimated Daily Intake (mg/kg/day)
ORGANICS				
Benzene	2.47E-10	1.92E-02	4.74E-12	4.22E-13
Benzoic Acid	1.35E-09	1.54E+01	2.08E-08	1.85E-09
Bis(2-ethylhexyl)phthalate	3.85E-07	7.70E-02	2.96E-08	2.63E-09
Bromodichloromethane	8.55E-10	3.85E-01	3.29E-10	2.92E-11
Butylbenzylphthalate	4.31E-08	1.54E+00	6.64E-08	5.90E-09
Carbon Tetrachloride	2.25E-10	3.85E-01	8.65E-11	7.69E-12
Chlorobenzene	2.19E-10	3.85E-01	8.42E-11	7.48E-12
Chloroform	3.90E-09	3.85E-01	1.50E-09	1.33E-10
Dibromochloromethane	2.40E-10	5.13E-01	1.23E-10	1.09E-11
Di-n-butylphthalate	6.31E-10	1.54E+00	9.72E-10	8.64E-11
Diethylphthalate	7.24E-10	1.54E+00	1.11E-09	9.91E-11
Dimethylphthalate	3.53E-10	1.54E+00	5.43E-10	4.82E-11
Dioxins/Furans (EPA TEFs)	8.75E-17	3.26E+02	2.85E-14	2.54E-15
Heptachlor epoxide	1.91E-11	1.54E+01	2.95E-10	2.62E-11
Methyl Chloride	2.80E-09	3.85E-01	1.08E-09	9.59E-11
Methylene Chloride	4.37E-10	3.85E-01	1.68E-10	1.50E-11
Styrene	2.11E-09	3.85E-01	8.11E-10	7.21E-11
Toluene	5.19E-10	4.81E-02	2.50E-11	2.22E-12
Xylene	2.15E-10	9.62E-03	2.07E-12	1.84E-13

Table 8G-3

Pollutant Concentrations in Breast Milk
Farmer Scenario

	DI Maximum Total Daily Intake (mg/kg/day)	TF Breast Milk Transfer Factor (day)	Maximum Breast Milk Conc. (mg/kg)	Maximum Estimated Daily Intake (mg/kg/day)
ORGANICS				
Benzene	4.32E-10	1.92E-02	8.32E-12	7.39E-13
Benzoic Acid	2.50E-09	1.54E+01	3.84E-08	3.42E-09
Bis(2-ethylhexyl)phthalate	2.41E-06	7.70E-02	1.86E-07	1.65E-08
Bromodichloromethane	1.50E-09	3.85E-01	5.77E-10	5.13E-11
Butylbenzylphthalate	2.22E-07	1.54E+00	3.42E-07	3.04E-08
Carbon Tetrachloride	3.94E-10	3.85E-01	1.52E-10	1.35E-11
Chlorobenzene	3.83E-10	3.85E-01	1.48E-10	1.31E-11
Chloroform	6.83E-09	3.85E-01	2.63E-09	2.34E-10
Dibromochloromethane	6.00E-10	5.13E-01	3.08E-10	2.74E-11
Di-n-butylphthalate	1.29E-09	1.54E+00	1.99E-09	1.77E-10
Diethylphthalate	1.75E-09	1.54E+00	2.69E-09	2.39E-10
Dimethylphthalate	1.03E-09	1.54E+00	1.59E-09	1.41E-10
Dioxins/Furans (EPA TEFs)	1.92E-16	3.26E+02	6.25E-14	5.56E-15
Heptachlor epoxide	7.96E-11	1.54E+01	1.23E-09	1.09E-10
Methyl Chloride	4.91E-09	3.85E-01	1.89E-09	1.68E-10
Methylene Chloride	7.67E-10	3.85E-01	2.95E-10	2.62E-11
Styrene	3.69E-09	3.85E-01	1.42E-09	1.26E-10
Toluene	9.10E-10	4.81E-02	4.38E-11	3.89E-12
Xylene	3.76E-10	9.62E-03	3.62E-12	3.22E-13

APPENDIX 8H

CARCINOGENIC RISK FOR INDIVIDUALS UNDER ALL SCENARIOS

Table 8H-1

Carcinogenic Risk Through all Routes of Exposure for the Adult, Resident-A Scenario

	VEGETABLE INGESTION CARC. RISK	MILK INGESTION CARC. RISK	BEEF INGESTION CARC. RISK	SOIL/DUST INGESTION CARC. RISK	FISH INGESTION CARC. RISK	DERMAL EXPOSURE CARC. RISK	TOTAL ADULT CARC. RISK
ORGANICS							
Benzene	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	2.76E-09	9.51E-12	1.09E-12	1.52E-14	8.43E-16	1.12E-14	2.77E-09
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA	NA	NA
Dibromochloromethane	3.60E-12	1.56E-16	6.08E-17	3.75E-14	8.30E-15	2.76E-14	3.68E-12
Dioxins/Furans (EPA TEFs)	8.57E-14	9.85E-15	8.39E-15	3.45E-14	8.49E-14	2.54E-14	2.49E-13
Heptachlor epoxide	6.73E-11	1.78E-14	5.46E-15	1.41E-13	1.04E-12	1.04E-13	6.86E-11
Methyl Chloride	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA
INORGANICS							
Arsenic	1.02E-11	6.38E-12	8.37E-14	7.25E-12	1.37E-12	5.33E-12	3.06E-11
Cadmium	NA	NA	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA
Total	2.84E-09	1.59E-11	1.19E-12	7.48E-12	2.50E-12	5.50E-12	2.87E-09

Table 8H-2

Carcinogenic Risk Through all Routes of Exposure for the Adult, Resident-B Scenario

	VEGETABLE INGESTION CARC. RISK	MILK INGESTION CARC. RISK	BEEF INGESTION CARC. RISK	SOIL/DUST INGESTION CARC. RISK	FISH INGESTION CARC. RISK	DERMAL EXPOSURE CARC. RISK	TOTAL ADULT CARC. RISK
ORGANICS							
Benzene	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	4.49E-09	9.51E-12	1.09E-12	2.48E-14	8.43E-16	1.82E-14	4.50E-09
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA	NA	NA
Dibromochloromethane	5.78E-12	1.56E-16	6.08E-17	6.09E-14	8.30E-15	4.48E-14	5.90E-12
Dioxins/Furans (EPA TEFs)	7.66E-14	9.85E-15	8.39E-15	5.61E-14	8.49E-14	4.12E-14	2.77E-13
Heptachlor epoxide	1.09E-10	1.78E-14	5.46E-15	2.29E-13	1.04E-12	1.69E-13	1.11E-10
Methyl Chloride	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA
INORGANICS							
Arsenic	3.46E-12	6.38E-12	8.37E-14	1.18E-11	1.37E-12	8.67E-12	3.17E-11
Cadmium	NA	NA	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA
Total	4.60E-09	1.59E-11	1.19E-12	1.21E-11	2.50E-12	8.94E-12	4.64E-09

Table 8H-3

Carcinogenic Risk Through all Routes of Exposure for the Adult, Farmer Scenario

	VEGETABLE INGESTION CARC. RISK	MILK INGESTION CARC. RISK	BEEF INGESTION CARC. RISK	SOIL/DUST INGESTION CARC. RISK	FISH INGESTION CARC. RISK	DERMAL EXPOSURE CARC. RISK	TOTAL ADULT CARC. RISK
ORGANICS							
Benzene	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	2.32E-08	1.90E-10	2.17E-11	1.48E-14	8.43E-16	5.34E-14	2.34E-08
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA	NA	NA
Dibromochloromethane	2.34E-11	3.11E-15	1.22E-15	3.64E-14	8.30E-15	1.31E-13	2.36E-11
Dioxins/Furans (EPA TEFs)	3.46E-13	1.97E-13	1.68E-13	3.35E-14	8.49E-14	1.21E-13	9.50E-13
Heptachlor epoxide	5.64E-10	3.55E-13	1.09E-13	1.37E-13	1.04E-12	4.95E-13	5.66E-10
Methyl Chloride	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA
INORGANICS							
Arsenic	7.80E-12	1.28E-10	1.67E-12	7.04E-12	1.37E-12	2.54E-11	1.71E-10
Cadmium	NA	NA	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA
Total	2.38E-08	3.18E-10	2.37E-11	7.26E-12	2.50E-12	2.62E-11	2.42E-08

Table 8H-4

Carcinogenic Risk Through all Routes of Exposure for the Adult, Worker Scenario

	INHALATION CARC. RISK	SOIL/DUST INGESTION CARC. RISK	DERMAL EXPOSURE CARC. RISK	TOTAL WORKER CARC. RISK
ORGANICS				
Benzene	1.06E-13	NA	NA	1.06E-13
Bis(2-ethylhexyl)phthalate	8.01E-14	6.36E-15	2.64E-14	1.13E-13
Bromodichloromethane	7.83E-13	NA	NA	7.83E-13
Carbon Tetrachloride	4.31E-13	NA	NA	4.31E-13
Chloroform	4.66E-12	NA	NA	4.66E-12
Dibromochloromethane	1.97E-13	1.56E-14	6.50E-14	2.78E-13
Dioxins/Furans (EPA TEFs)	1.37E-13	1.44E-14	5.99E-14	2.11E-13
Heptachlor epoxide	7.43E-13	5.89E-14	2.45E-13	1.05E-12
Methyl Chloride	2.61E-13	NA	NA	2.61E-13
Methylene Chloride	9.04E-14	NA	NA	9.04E-14
Styrene	6.22E-14	NA	NA	6.22E-14
INORGANICS				
Arsenic	3.27E-10	3.02E-12	1.26E-11	3.42E-10
Cadmium	6.79E-12	NA	NA	6.79E-12
Chromium VI	1.88E-11	NA	NA	1.88E-11
Nickel	1.74E-13	NA	NA	1.74E-13
Total	3.60E-10	3.12E-12	1.30E-11	3.76E-10

Table 8H-5

Carcinogenic Risk Through all Routes of Exposure for the Child, Resident-A Scenario

	INHALATION CARC. RISK	VEGETABLE INGESTION CARC. RISK	MILK INGESTION CARC. RISK	BEEF INGESTION CARC. RISK	SOIL/DUST INGESTION CARC. RISK	FISH INGESTION CARC. RISK	DERMAL EXPOSURE CARC. RISK	TOTAL CHILD CARC. RISK
ORGANICS								
Benzene	1.16E-12	NA	NA	NA	NA	NA	NA	1.16E-12
Bis(2-ethylhexyl)phthalate	8.83E-13	3.23E-10	4.29E-12	2.12E-13	1.08E-14	1.49E-16	7.33E-15	3.28E-10
Bromodichloromethane	8.62E-12	NA	NA	NA	NA	NA	NA	8.62E-12
Carbon Tetrachloride	4.75E-12	NA	NA	NA	NA	NA	NA	4.75E-12
Chloroform	5.14E-11	NA	NA	NA	NA	NA	NA	5.14E-11
Dibromochloromethane	2.17E-12	4.68E-13	7.02E-17	1.18E-17	2.64E-14	1.46E-15	1.80E-14	2.69E-12
Dioxins/Furans (EPA TEFs)	1.51E-12	1.15E-14	5.06E-15	1.78E-15	2.43E-14	1.50E-14	1.66E-14	1.58E-12
Heptachlor epoxide	8.18E-12	7.88E-12	8.02E-15	1.06E-15	9.97E-14	1.83E-13	6.79E-14	1.64E-11
Methyl Chloride	2.87E-12	NA	NA	NA	NA	NA	NA	2.87E-12
Methylene Chloride	9.96E-13	NA	NA	NA	NA	NA	NA	9.96E-13
Styrene	6.86E-13	NA	NA	NA	NA	NA	NA	6.86E-13
INORGANICS								
Arsenic	3.60E-09	1.44E-12	2.88E-12	1.63E-14	5.12E-12	2.42E-13	3.48E-12	3.61E-09
Cadmium	7.48E-11	NA	NA	NA	NA	NA	NA	7.48E-11
Chromium VI	2.07E-10	NA	NA	NA	NA	NA	NA	2.07E-10
Nickel	1.92E-12	NA	NA	NA	NA	NA	NA	1.92E-12
Total	3.97E-09	3.33E-10	7.18E-12	2.31E-13	5.28E-12	4.41E-13	3.59E-12	4.32E-09

Table 8H-6

Carcinogenic Risk Through all Routes of Exposure for the Child, Resident-B Scenario

	INHALATION CARC. RISK	VEGETABLE INGESTION CARC. RISK	MILK INGESTION CARC. RISK	BEEF INGESTION CARC. RISK	SOIL/DUST INGESTION CARC. RISK	FISH INGESTION CARC. RISK	DERMAL EXPOSURE CARC. RISK	TOTAL CHILD CARC. RISK
ORGANICS								
Benzene	2.31E-13	NA	NA	NA	NA	NA	NA	2.31E-13
Bis(2-ethylhexyl)phthalate	1.75E-13	5.25E-10	4.29E-12	2.12E-13	1.75E-14	1.49E-16	1.19E-14	5.30E-10
Bromodichloromethane	1.71E-12	NA	NA	NA	NA	NA	NA	1.71E-12
Carbon Tetrachloride	9.42E-13	NA	NA	NA	NA	NA	NA	9.42E-13
Chloroform	1.02E-11	NA	NA	NA	NA	NA	NA	1.02E-11
Dibromochloromethane	4.31E-13	7.51E-13	7.02E-17	1.18E-17	4.30E-14	1.46E-15	2.93E-14	1.26E-12
Dioxins/Furans (EPA TEFs)	2.99E-13	9.57E-15	5.06E-15	1.78E-15	3.96E-14	1.50E-14	2.69E-14	3.97E-13
Heptachlor epoxide	1.62E-12	1.28E-11	8.02E-15	1.06E-15	1.62E-13	1.83E-13	1.10E-13	1.49E-11
Methyl Chloride	5.70E-13	NA	NA	NA	NA	NA	NA	5.70E-13
Methylene Chloride	1.98E-13	NA	NA	NA	NA	NA	NA	1.98E-13
Styrene	1.36E-13	NA	NA	NA	NA	NA	NA	1.36E-13
INORGANICS								
Arsenic	7.14E-10	4.37E-13	2.88E-12	1.63E-14	8.31E-12	2.42E-13	5.66E-12	7.32E-10
Cadmium	1.48E-11	NA	NA	NA	NA	NA	NA	1.48E-11
Chromium VI	4.10E-11	NA	NA	NA	NA	NA	NA	4.10E-11
Nickel	3.80E-13	NA	NA	NA	NA	NA	NA	3.80E-13
Total	7.87E-10	5.39E-10	7.18E-12	2.31E-13	8.57E-12	4.41E-13	5.84E-12	1.35E-09

Table 8H-7

Carcinogenic Risk Through all Routes of Exposure for the Child, Farmer Scenario

	INHALATION CARC. RISK	VEGETABLE INGESTION CARC. RISK	MILK INGESTION CARC. RISK	BEEF INGESTION CARC. RISK	SOIL/DUST INGESTION CARC. RISK	FISH INGESTION CARC. RISK	DERMAL EXPOSURE CARC. RISK	TOTAL CHILD CARC. RISK
ORGANICS								
Benzene	4.04E-13	NA	NA	NA	NA	NA	NA	4.04E-13
Bis(2-ethylhexyl)phthalate	3.07E-13	3.90E-09	8.58E-11	4.24E-12	1.04E-14	1.49E-16	7.11E-15	3.99E-09
Bromodichloromethane	3.00E-12	NA	NA	NA	NA	NA	NA	3.00E-12
Carbon Tetrachloride	1.65E-12	NA	NA	NA	NA	NA	NA	1.65E-12
Chloroform	1.79E-11	NA	NA	NA	NA	NA	NA	1.79E-11
Dibromochloromethane	7.55E-13	3.93E-12	1.40E-15	2.37E-16	2.57E-14	1.46E-15	1.75E-14	4.73E-12
Dioxins/Furans (EPA TEFs)	5.23E-13	5.77E-14	1.01E-13	3.55E-14	2.36E-14	1.50E-14	1.61E-14	7.72E-13
Heptachlor epoxide	2.84E-12	9.48E-11	1.60E-13	2.13E-14	9.68E-14	1.83E-13	6.59E-14	9.82E-11
Methyl Chloride	9.99E-13	NA	NA	NA	NA	NA	NA	9.99E-13
Methylene Chloride	3.46E-13	NA	NA	NA	NA	NA	NA	3.46E-13
Styrene	2.38E-13	NA	NA	NA	NA	NA	NA	2.38E-13
INORGANICS								
Arsenic	1.25E-09	1.11E-12	5.76E-11	3.26E-13	4.97E-12	2.42E-13	3.38E-12	1.32E-09
Cadmium	2.60E-11	NA	NA	NA	NA	NA	NA	2.60E-11
Chromium VI	7.19E-11	NA	NA	NA	NA	NA	NA	7.19E-11
Nickel	6.66E-13	NA	NA	NA	NA	NA	NA	6.66E-13
Total	1.38E-09	4.00E-09	1.44E-10	4.62E-12	5.12E-12	4.41E-13	3.49E-12	5.54E-09

Table 8H-8

Carcinogenic Risk Through all Routes of Exposure for the Infant, Resident-A Scenario

	INHALATION CARC. RISK	BREAST MILK INGESTION CARC. RISK	TOTAL INFANT CARC. RISK
ORGANICS			
Benzene	7.61E-13	8.81E-16	7.62E-13
Bis(2-ethylhexyl)phthalate	5.78E-13	3.41E-13	9.19E-13
Bromodichloromethane	5.64E-12	1.31E-13	5.77E-12
Carbon Tetrachloride	3.11E-12	7.20E-14	3.18E-12
Chloroform	3.36E-11	5.86E-14	3.37E-11
Dibromochloromethane	1.42E-12	4.76E-14	1.47E-12
Dioxins/Furans (EPA TEFs)	9.86E-13	2.66E-11	2.75E-11
Heptachlor epoxide	5.36E-12	6.58E-12	1.19E-11
Methyl Chloride	1.88E-12	8.98E-14	1.97E-12
Methylene Chloride	6.52E-13	8.09E-15	6.60E-13
Styrene	4.49E-13	1.56E-13	6.05E-13
INORGANICS			
Arsenic	2.36E-09	NE	2.36E-09
Cadmium	4.89E-11	NA	4.89E-11
Chromium VI	1.35E-10	NA	1.35E-10
Nickel	1.25E-12	NA	1.25E-12
Total	2.60E-09	3.40E-11	2.63E-09

Table 8H-9

Carcinogenic Risk Through all Routes of Exposure for the Infant, Resident-B Scenario

	INHALATION CARC. RISK	BREAST MILK INGESTION CARC. RISK	TOTAL INFANT CARC. RISK
ORGANICS			
Benzene	1.51E-13	1.75E-16	1.51E-13
Bis(2-ethylhexyl)phthalate	1.15E-13	5.26E-13	6.41E-13
Bromodichloromethane	1.12E-12	2.59E-14	1.15E-12
Carbon Tetrachloride	6.17E-13	1.43E-14	6.31E-13
Chloroform	6.66E-12	1.16E-14	6.68E-12
Dibromochloromethane	2.82E-13	1.31E-14	2.95E-13
Dioxins/Furans (EPA TEFs)	1.95E-13	5.44E-12	5.63E-12
Heptachlor epoxide	1.06E-12	3.41E-12	4.47E-12
Methyl Chloride	3.73E-13	1.78E-14	3.91E-13
Methylene Chloride	1.29E-13	1.60E-15	1.31E-13
Styrene	8.90E-14	3.09E-14	1.20E-13
INORGANICS			
Arsenic	4.67E-10	NE	4.67E-10
Cadmium	9.71E-12	NA	9.71E-12
Chromium VI	2.69E-11	NA	2.69E-11
Nickel	2.49E-13	NA	2.49E-13
Total	5.15E-10	9.48E-12	5.24E-10

Table 8H-10

Carcinogenic Risk Through all Routes of Exposure for the Infant, Farmer Scenario

	INHALATION CARC. RISK	BREAST MILK INGESTION CARC. RISK	TOTAL INFANT CARC. RISK
ORGANICS			
Benzene	2.65E-13	3.06E-16	2.65E-13
Bis(2-ethylhexyl)phthalate	2.01E-13	3.30E-12	3.50E-12
Bromodichloromethane	1.96E-12	4.54E-14	2.01E-12
Carbon Tetrachloride	1.08E-12	2.50E-14	1.11E-12
Chloroform	1.17E-11	2.04E-14	1.17E-11
Dibromochloromethane	4.94E-13	3.29E-14	5.27E-13
Dioxins/Furans (EPA TEFs)	3.43E-13	1.19E-11	1.22E-11
Heptachlor epoxide	1.86E-12	1.42E-11	1.60E-11
Methyl Chloride	6.54E-13	3.12E-14	6.85E-13
Methylene Chloride	2.27E-13	2.81E-15	2.29E-13
Styrene	1.56E-13	5.42E-14	2.10E-13
INORGANICS			
Arsenic	8.19E-10	NE	8.19E-10
Cadmium	1.70E-11	NA	1.70E-11
Chromium VI	4.71E-11	NA	4.71E-11
Nickel	4.36E-13	NA	4.36E-13
Total	9.02E-10	2.96E-11	9.32E-10

APPENDIX 9A

DERIVATION OF SELECTED ORAL REFERENCE DOSES (RfDs)

APPENDIX 9A

DERIVATION OF SELECTED ORAL REFERENCE DOSES (RfDs)

In many instances it was necessary to derive an oral RfD from existing toxicity data. Chronic oral toxicity data were used, when available. In the absence of chronic data subchronic or acute oral toxicity data were used.

9A.1 Derivation from No-Observable-Adverse-Effect Levels (NOAELs)

An oral RfD for benzene was calculated from the NOAEL according to EPA guidelines (EPA, 1989). The RfD for benzene was based on a NOAEL of 1 mg/kg/day from a 26-week study in rats. The toxic endpoints manifested in the rats were leukopenia and erythrocytopenia (Wolfe et al., 1956). To extrapolate the oral RfD from the NOAEL, uncertainty factors (UFs) were included. The total UF of 1,000 was calculated by multiplying by 10 for each of the following categories: subchronic to chronic exposure, animal to humans, and human variation. The chronic RfD was then calculated by dividing the NOAEL by the UF of 1,000.

9A.2 Derivation from Oral Lethality Data

In the absence of chronic and subchronic toxicity data, an oral LD_{50} was used to derive the chronic oral RfD for methyl chloride. An LD_{50} is the dose that is lethal to 50% of the test animals. The chronic oral RfD was calculated by dividing the LD_{50} by an uncertainty factor (UF) of 100,000 in accordance with the approach developed by Layton et. al., (1987).

APPENDIX 9A

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Table 9A-1

Chronic Oral Reference Doses (RfDs) Derived from LD_{50} Values

Chemical	LD50 (mg/kg)	Test Species	Chronic Oral RfD (mg/kg/day)
Methyl Chloride	1,800	rat	2.50E-03

Reference : RTECS, 1990